BIENNIAL REPORT

2019-2020

INSTITUTE OF VERTEBRATE BIOLOGY

THE CZECH ACADEMY OF SCIENCES

BRNO 2021

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2019-2020

INSTITUTE OF VERTEBRATE BIOLOGY
CZECH ACADEMY OF SCIENCES

A periodical continuation of the Institute's previous bulletins: Vertebratologické zprávy (1969-1987), Zprávy ÚSEB (1988-1991) and the ILE Biennial Report (1993-1994).

Edited by Alena Fornůsková, Hana Slabáková and Jan Zukal

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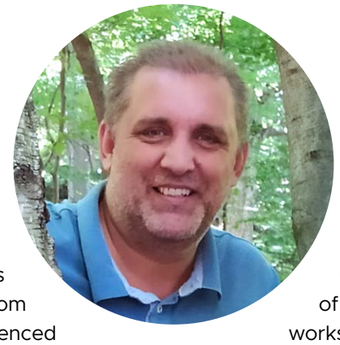
Dear reader,



after an extremely unconventional period caused by the COVID-19 pandemic, we have prepared a summary of our activities in the new Biennial Report. The last two years have been really different from many points of view. We experienced a changeover in the Director of the Institute in mid-June 2019, there was the regular international evaluation and, finally, there were all the challenges associated with the COVID-19 pandemic, which dramatically changed both our private and professional lives.

Fortunately, this Biennial Report shows that even in such unfavorable times, our research activities were not stopped and we were able to produce important results. Our three scientific divisions, which focus on groundbreaking research in the fields of evolutionary biology, biodiversity and medical zoology, produced around 110 scientific publications each year in peer-reviewed journals.

We also strengthened and expanded our public relations activities, which now represents an important aspect of all our work. The new public relations team, formed in 2019, have achieved impressive results in the popularisation of our activities and results, despite the COVID-19 pandemic severely limiting the possibilities of attending public events and workshops and conferences for students at all levels of education.

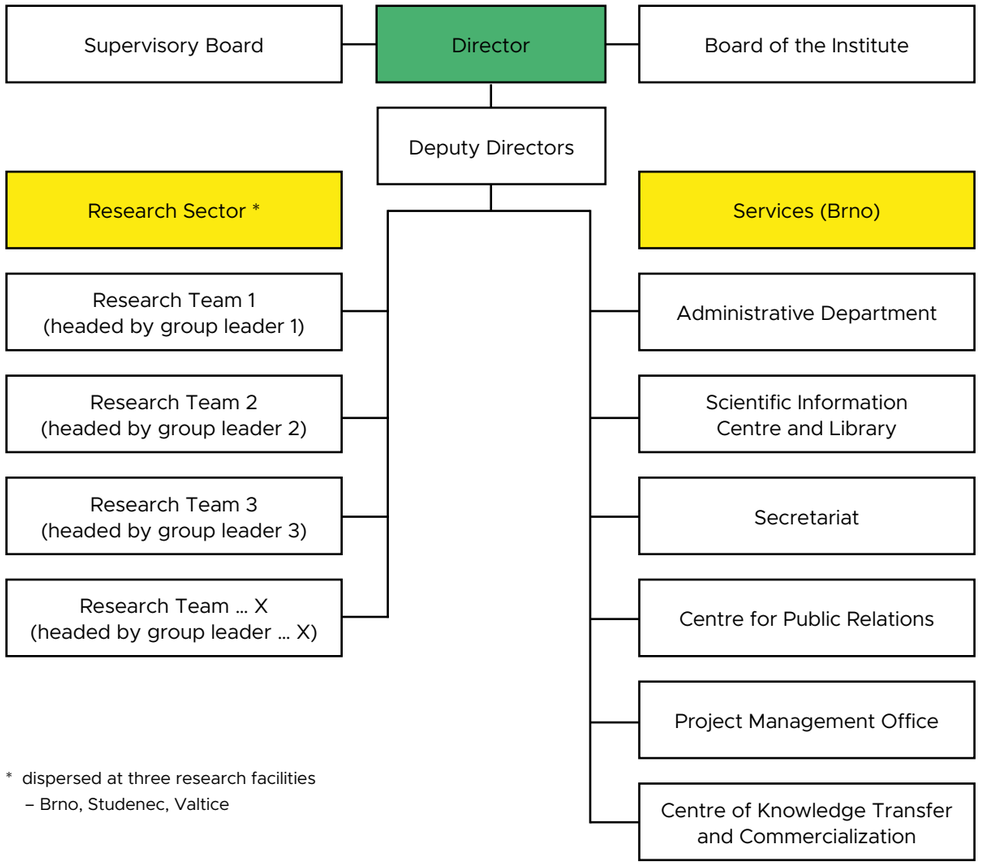
I believe that the information contained in this Biennial Report will be of great interest, not only to our co-workers but also to our colleagues at other scientific and educational institutions as well as the general public. Furthermore, I believe this will only be enhanced by the brand new design of the Biennial Report.

I wish you pleasant reading,

doc. Mgr. Jan Zukal, Dr., MBA
Director of the Institute
of Vertebrate Biology of CAS

BACKGROUND

STRUCTURE OF THE INSTITUTE OF VERTEBRATE BIOLOGY



* dispersed at three research facilities – Brno, Studenec, Valtice

The Institute of Vertebrate Biology (IVB) is a relatively small institute of the Czech Academy of Sciences and, as such, is not structured into separate research departments. Senior researchers are usually the Principle Investigators of national and international projects and are responsible for creating and maintaining their teams, predominantly from external funds. Principle Investigators (group leaders) of projects are directly subordinated to the Director. Research teams are highly flexible and are composed of junior researchers, post-doctorates, research assistants, technicians and pre- and post-graduate students (mostly paid from project grants). Research subjects can be divided into three main domains: evolutionary ecology, biodiversity and pathogens and diseases (see below). However, individual projects can cover more topics and researchers often use interdisciplinary approaches.

RESEARCH STAFF

Only people with an employment contract are shown, i.e. not all PhD students are listed (for a complete list of PhD students see below). Numerous fellows contracted on the basis of external grant funding have only part-time jobs (extent not shown here), often limited to short periods.

Brno Research Facility

The research facilities in Brno include zoological collections, a breeding facility for experimental fish (including facilities for semi-natural experiments), a basic laboratory for molecular genetics studies, a parasitological and ichthyological laboratory and high-quality equipment for field research. Research teams at Brno use model vertebrate groups to study basic questions in the fields of ecology and evolutionary biology, ethology, applied zoology, the roles of parasites and invasive species and protection and management of freshwater and terrestrial ecosystems. The main topics studied include:

+ **reproductive strategies in fishes and birds**
+ **adaptation and coevolution between parasites and hosts (e.g. cuckoo vs. passerine birds, bitterling vs. bivalves)**
+ **population biology, ecology and biogeography of annual fishes (e.g. *Nothobranchius*, *Cynolebias*)**
+ **relationships between metazoan parasites and their hosts (fish, birds)**
+ **fish communities and populations of key species in various aquatic habitats**
+ **invasive species in the aquatic environment**
+ **migration connectivity and seasonal interaction of long-distance bird migrants**
+ **ecology and behaviour of bats, especially during hibernation**
+ **population genetics and interspecies hybridisation in deer**
+ **ecology and conservation of carnivores in fragmented landscapes**
+ **food ecology of herbivorous mammals and their impact on the environment**
+ **diet and parasites of primates**

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Valtice Research Facility

The Valtice research facility is well equipped with both state-of-the-art molecular equipment and a animal rearing facility that fulfils all safety requirements needed for the handling of laboratory animals. Research is mainly focused on ecology and eco-epidemiology of zoonotic microorganisms, with a main emphasis on emerging and re-emerging pathogens. In particular, research focusses on the role of endotherm vertebrates (hosts to pathogenic agents) and haematophagous arthropods (biological vectors) in the circulation of zoonotic pathogens, along with the natural and socio-economic factors driving emergence of particular infections. The main issues addressed include:

+ **isolation and identification of novel microorganisms, including human pathogens (microbe hunting)**
+ **ecology of arthropod-borne microorganisms (e.g. West Nile and tick-borne encephalitis flaviviruses, spirochaete *Borrelia burgdorferi*, rickettsiae *Anaplasma phagocytophilum*, the spotted fever group rickettsiae and Babesia spp. protozoa)**
+ **implementing the 'one health' concept for studying emerging zoonoses**
+ **risk of introduction and establishment of new mosquito invasive vectors and mosquito-borne diseases into Central Europe**
+ **providing expert advice regarding prevention and control of zoonoses (contribution to preventive human and veterinary medicine)**
+ **providing expert opinion on emerging infectious diseases**

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Studenec Research Facility

The Studenec research facility is a very dynamic part of the Institute that has evolved significantly over recent years. It houses modern, well equipped molecular-genetic, physiological and microscopic laboratories, a breeding facility for small mammals, birds and amphibians and facilities allowing experimentation under semi-natural conditions. Empirical data from observations, laboratory analysis and experiments (supplemented by simulation modelling) are used to investigate important evolutionary questions, mainly at the population level. Research activities are mostly fundamental but may have applications in biomedicine, species conservation and epidemiology. Examples of research topics (model organisms given in parentheses) include:

+ **hybrid zones as barriers against gene flow and their role in speciation (rodents, amphibians)**
+ **phylogeography, reconstruction of historical colonisation and mechanisms of biodiversity evolution (mainly African rodents and amphibians)**
+ **study of factors affecting population structure, conservation genetics (fish, birds, rodents, carnivores)**
+ **mating systems, analysis of reproductive success and factors affecting fitness (passerine birds)**
+ **immunogenetics, links between adaptive genetic variation and fitness (rodents, passerine birds)**
+ **host-parasite co-evolution, genetic variation in pathogens and their hosts (rodents, bats, pathogenic fungi, helminths, RNA-viruses)**
+ **mechanisms and evolution of thermal physiology traits in ectotherms (newts)**
+ **functional approaches in the study of morphological adaptation (amphibians and reptiles)**

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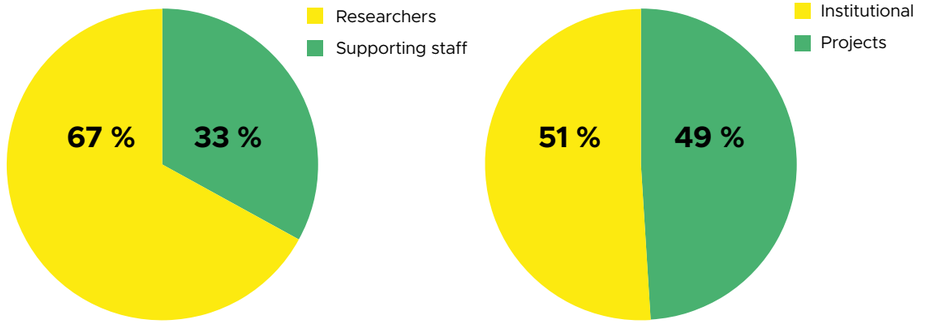
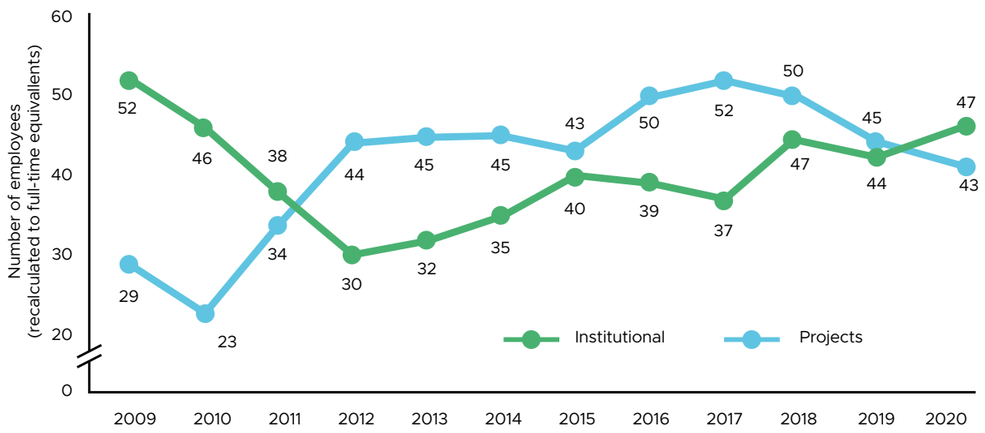
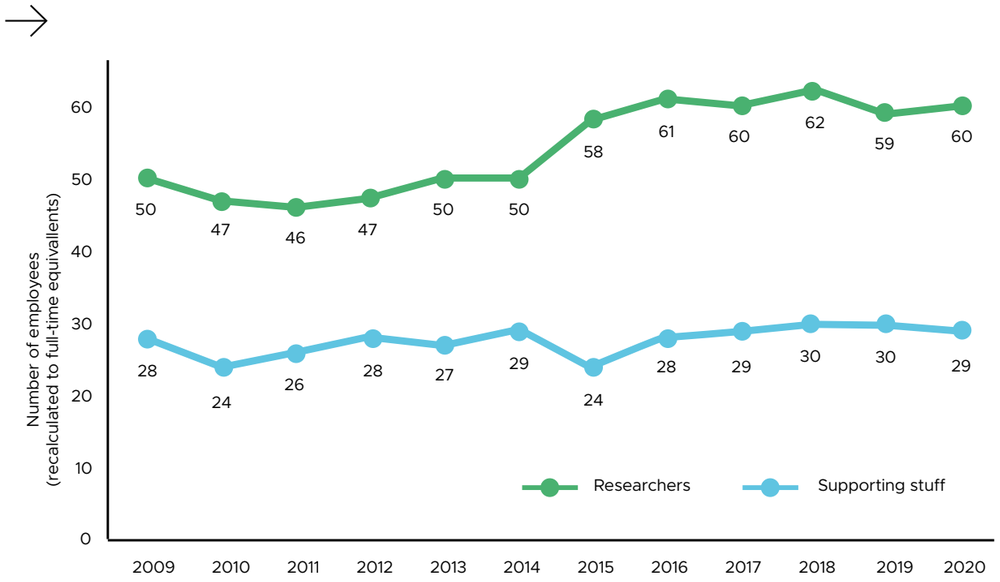
STAFF AND BUDGET



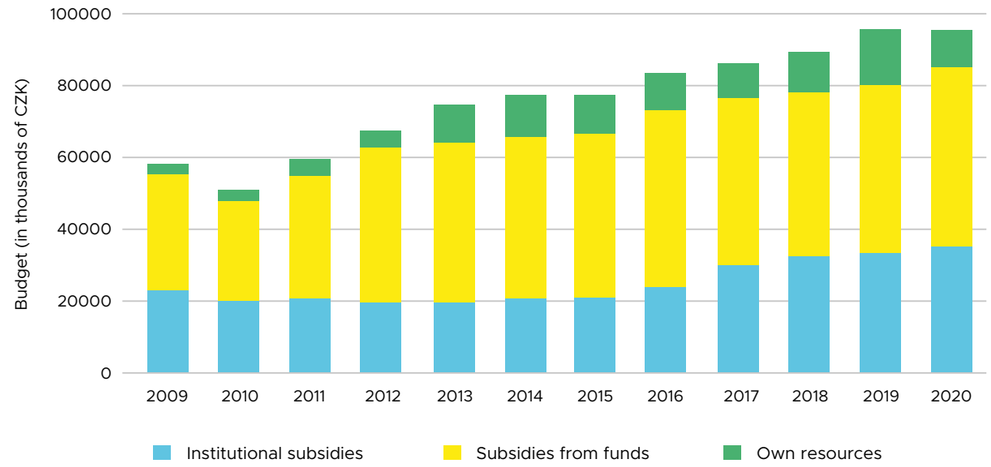
Staff structure over the period 2019-2020



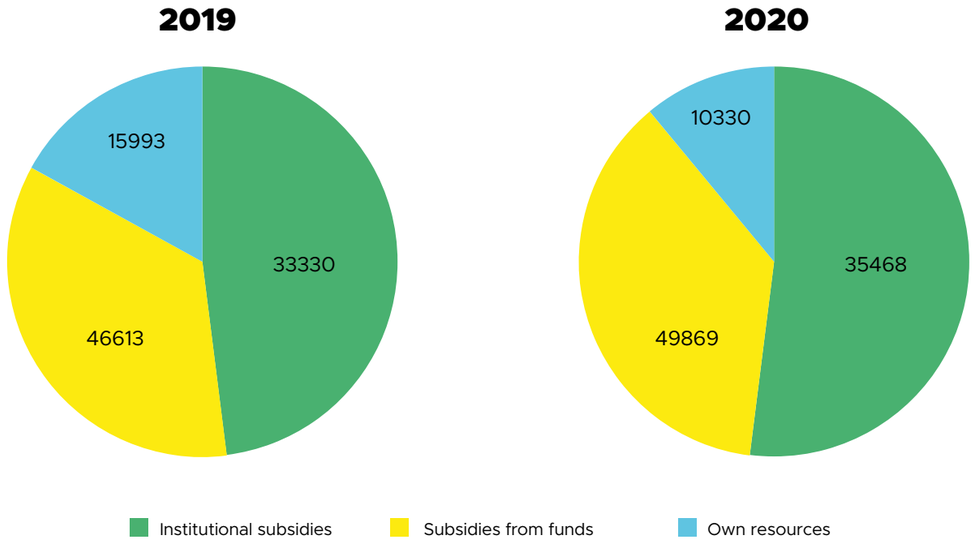
The number of employees paid from institutional sources increased in 2020 and for the first time in last 10 years their number exceeded number of employees paid from projects



Budget structure (numbers represent thousands of CZK)



The number of employees has been more or less the same in recent years, but the proportion of those paid from more stable institutional sources has increased



The total budget of the Institute remain stable over last two years

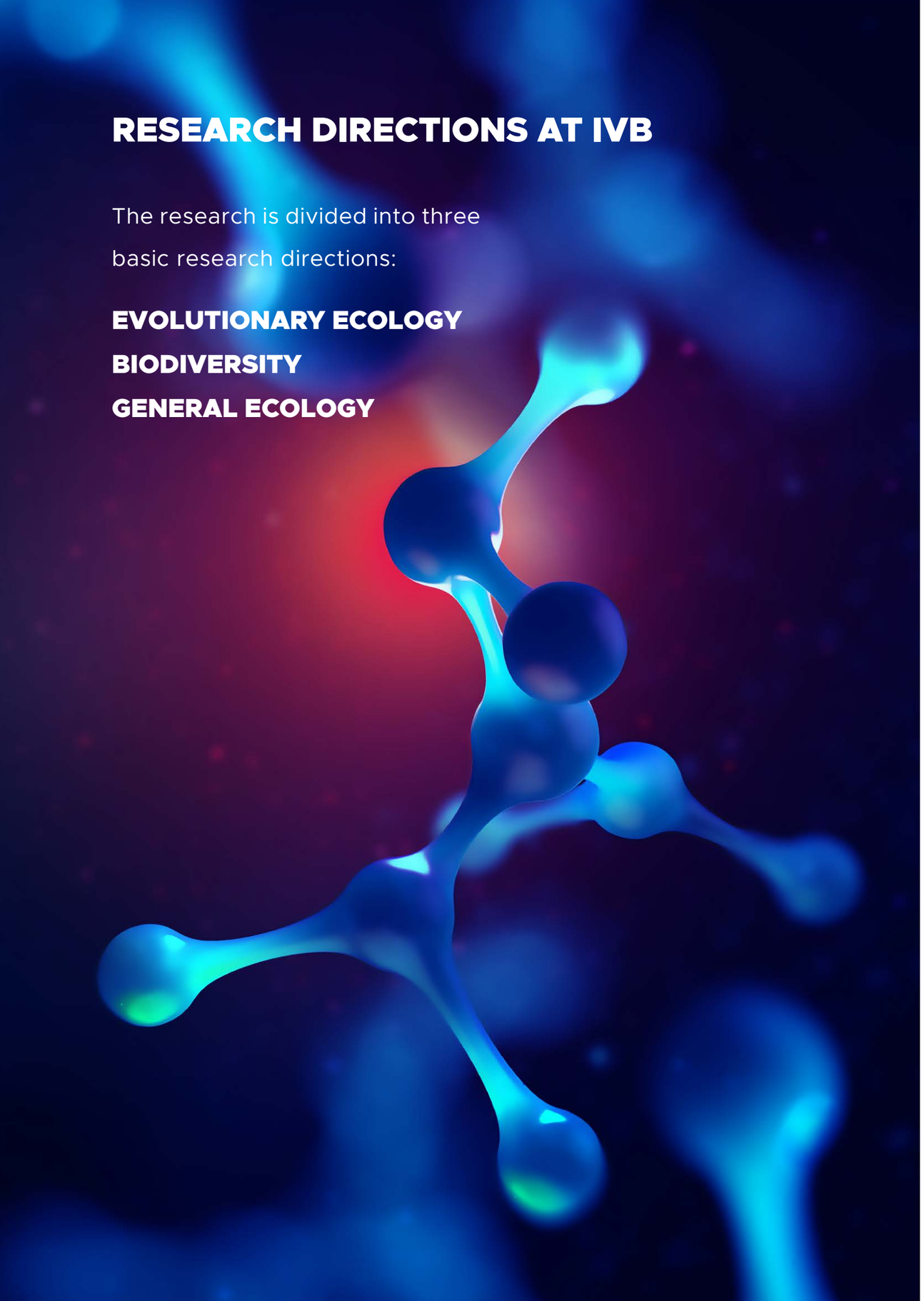
RESEARCH DIRECTIONS AT IVB

The research is divided into three basic research directions:

EVOLUTIONARY ECOLOGY

BIODIVERSITY

GENERAL ECOLOGY



Research in the **Division of Evolutionary Ecology** examines how ecological factors affects evolutionary change, and how evolutionary patterns are linked to ecological processes. Specifically, we study how reproductive biology and life histories evolve within and among species, how they respond to environmental change, and how organismal form coevolves with the function. The typical research topics include:

+ **evolution of life histories and ageing**
+ **sexual selection, evolution of mating systems and reproductive behaviour**
+ **brood parasitism in avian and fish study systems**
+ **coevolution of predator-prey and host-parasite interactions**
+ **migration and dispersal biology**
+ **thermal physiology and individual energetics**
+ **functional approaches to morphological adaptations**

The research performed in the **Division of Biodiversity** focuses mainly on evolutionary processes affecting diversity of vertebrates (as holobionts, i.e. host plus its symbionts) at species and intraspecific (genetic) level, including factors responsible for its increase (e.g. speciation) and decrease (conservation genetics, extinctions of populations). Individual projects deal mainly with the following issues:

+ **speciation, hybridization**
+ **evolutionary history, phylogeography – origin of current genetic diversity and its spatial distribution;**
+ **factors affecting holobiont diversity, e.g. host-parasite co-evolution and microbiome structure**
+ **biogeography, evolution of biodiversity hot-spots (especially in Africa)**
+ **genetic threats of contemporary populations, conservation genetics**
+ **biological collections, biobanking**

The aim of research in the **Division of General Ecology** is an interdisciplinary and comprehensive study of ecological interactions among vertebrates and their environment, which includes both environmental and socio-economic drivers. The typical research topics focus on:

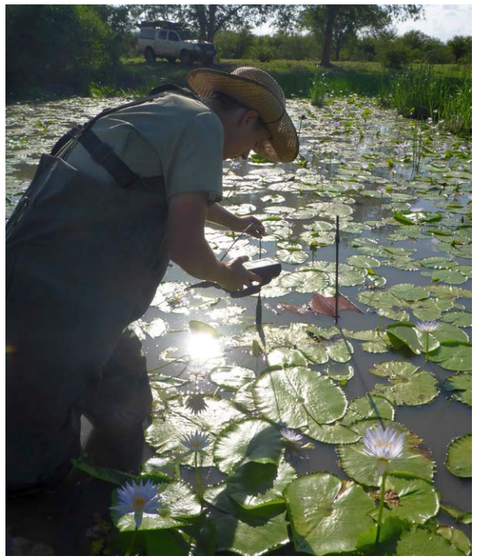
+ **functioning of ecosystems (especially in agricultural landscape)**
+ **community structure and its changes**
+ **diseases ecology including biology of vectors and eco-epidemiology of zoonoses**
+ **implementation of the ‘One health’ concept for the study of emerging pathogens**
+ **foraging/feeding activity including food structure**
+ **habitat preferences**
+ **conservation ecology of endangered species**
+ **ecology of hibernation**

EVOLUTIONARY ECOLOGY

FISH EVOLUTIONARY ECOLOGY GROUP

Evolutionary processes shaping the life history of annual killifish

Annual killifish are small freshwater fish living in seasonal pools in Africa and the Americas. These habitats only form during the rainy season and dry out completely in the dry season. To survive these seasonal changes, the annual killifish has developed a range of adaptations. Their embryos, for example, survive the drought period encased in the dry pool sediments. The embryos are so well protected that the eggs can pass through a waterbird's digestive system and successfully colonise relatively distant habitats. The growth of these fish is particularly flexible and depends closely on the current pool conditions. The annual killifish's constrained lifespan and their small population sizes, however, weaken the natural selection that would normally purge deleterious mutations from the genome. As such, the life-history strategy of annual killifish represents an evolutionary trap that forces these mutations to slowly accumulate. Individuals frequently suffer from genetic disorders and the fish are extremely short-lived, even under benign captive conditions. At the macroecological level, there appears to be little opportunity for evolutionary diversification in annual killifish clades.



Collecting data on annual killifish diel activity in the wild. | Photo by M. Vrtílek

The growth of annual killifish (including the Uruguayan species Austrolebias bellottii in this picture) is extremely plastic, being highly sensitive to the species composition, population density and other parameters found in individual pools. | Photo by R. Blažek

Reichard M, Polačik M (2019). *Nothobranchius furzeri*, an 'instant' fish from an ephemeral habitat. *eLife*, **8**, e41548.

Cui R, Medeiros T, Willemsen D, Iasi LNM, Collier GE, Graef M, **Reichard M**, Valenzano DR (2019). Relaxed selection limits lifespan by increasing mutation load. *Cell*, **178**, 385-399.e20.

Silva GG, Weber V, Green AJ, Hoffmann P, Silva VS, Volcan MV, Lanés LEK, Stenert C, **Reichard M**, Maltchik L (2019). Killifish eggs can disperse via gut passage through waterfowl. *Ecology*, **100**, e02774.

García D, Smith C, Machín E, Loureiro M, **Reichard M** (2019). Changing patterns of growth in a changing planet: How a shift in phenology affects critical life-history traits in annual fishes. *Freshwater Biology*, **64**, 1848-1858.

Lambert JW, **Reichard M**, Pincheira-Donoso D (2019). Live fast, diversify non-adaptively: evolutionary diversification of exceptionally short-lived annual killifishes. *BMC Evolutionary Biology*, **19**, 10.

Vrtílek M, Žák J, Polačik M, Blažek R, Reichard M (2019). Rapid growth and large body size in annual fish populations are compromised by density-dependent regulation. *Journal of Fish Biology*, **95**, 673-678.

Žák J, Vrtílek M, Reichard M (2019). Diel schedules of locomotor, reproductive and feeding activity in wild populations of African annual killifish. *Biological Journal of the Linnean Society*, **128**, 435-450.

García D, Loureiro M, Machín E, **Reichard M** (2019). Species co-occurrence and population dynamics in annual fish assemblages in the lower Río Uruguay basin. *Environmental Biology of Fishes*, **102**, 569-580.

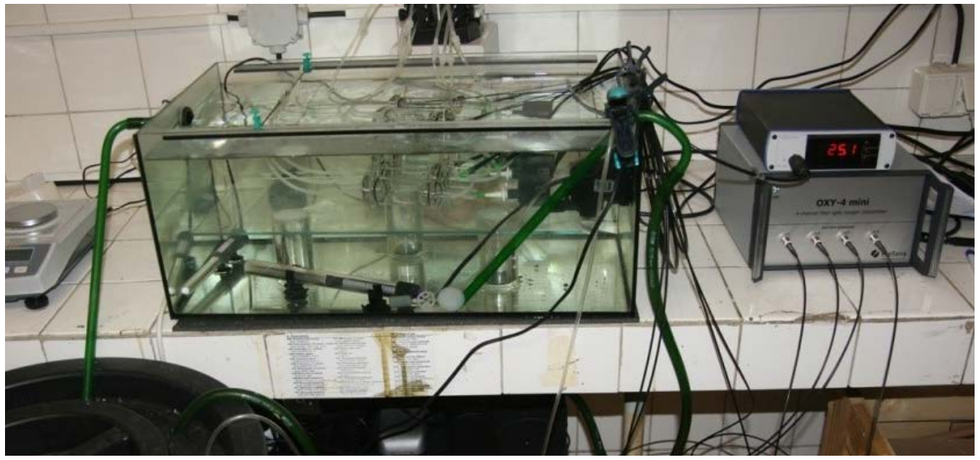
Willemsen D, Cui R, **Reichard M**, Valenzano DR (2020). Intraspecies differences in population size shape life history and genome evolution. *eLife*, **9**, e55794.

African annual killifish of the genus *Nothobranchius* under laboratory conditions

Ageing of African annual killifish has been comprehensively studied in many laboratories worldwide. A knowledge of the life history and behaviour of annual killifish is crucial for their successful husbandry. In testing for links between life history, behaviour and physiology, we predicted that individuals with a rapid life history (fast growth and maturation, short lifespan) would be more active and have a more intensive metabolism.

Surprisingly, we found no support for our predictions at the individual level. Conditions in captivity and in the wild differ in many aspects, with the pools inhabited by the annual killifish being much more variable compared to the laboratory setup. We set out to test the effect of oscillating temperature (daily fluctuation between 20 and 35°C, mirroring natural conditions) on annual killifish performance. Fish from the oscillation (natural) treatment were smaller, but lived significantly longer than those from the stable thermal regime. Wild annual killifish feed mainly on aquatic invertebrates and, to date, there has been no reliable substitute for live or frozen food in captivity, which carries the risk of introducing diseases and prevents manipulation of diet content.

We completed the first study on transition of annual killifish to a standardised pellet diet. Fish performance on the pelleted food was comparable to that when using the typical laboratory food for annual killifish, i.e. frozen bloodworms. Accessibility to standardised food is a critical condition for the use of this species as a laboratory model.



The flow respirometry setup for measuring annual killifish metabolism. | Photo by R. Blažek

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Cuckoo catfish can infest the brood of its host through multiple developmental stages

Cuckoo catfish (*Synodontis multipunctatus*) from Lake Tanganyika in Africa exploit the parental care behaviour of mouth-brooding cichlids, which incubate their own eggs and fry in their buccal cavity. The catfish parents intrude on the cichlid spawning process and lay their own eggs at the same time.

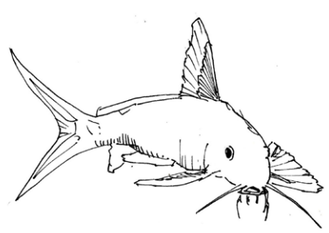
In the subsequent rush, the cichlid female collects the catfish eggs along with her own and inadvertently protects the cuckoo catfish offspring. However, catfish fry hatch earlier than cichlid fry and subsequently feed on the cichlid eggs. We showed that the cuckoo catfish can infest their host not only during the cichlid spawning process (by laying eggs) but also after hatching. Some of the eggs laid may be fall astray during the spawning turmoil and some survive, even without cichlid protection.

If they are lucky, these will be picked up later as cichlid mothers have a strong instinct to collect stray fry. In this way, the catfish exploit cichlid protection at two different developmental stages.

Our finding offers a new perspective on the potential evolution of brood parasitism within this system.

Mouth-brooding cichlid female parasitised by a cuckoo catfish. | Photo by R. Blažek

A cuckoo catfish juvenile. | Photo by M. Vrtílek



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EVOLUTIONARY ECOLOGY

BIRD ECOLOGY AND MIGRATION GROUP

Long-distance migration and the importance of understanding patterns in timing of the annual cycle and drivers of population dynamics in migratory birds

The investigation of long-distance migration spatiotemporal patterns is crucial for our understanding of a wide array of ecological and evolutionary mechanisms affecting migratory species. Use of a recent breakthrough, miniature light-level geolocators, allowed us to test for differences in the timing of migration between males and females across many species of long-distance migratory birds.

We were also able to observe differences in the timing of post-breeding and pre-breeding migration on the western and eastern migratory flyways, and documented wide variation in individual strategies when crossing the Sahara. In addition, we explored how conditions at a given stage carry over to the subsequent stages of the annual cycle and how climate change may influence the timing of arrival at the breeding grounds. Finally, we assessed whether demographic parameters were more strongly affected by climatic conditions on breeding or non-breeding grounds.

A good knowledge of migratory strategies and the temporal interdependence between individual stages of the annual cycle is vital, not only for effective conservation of declining migratory species but also for understanding how global climate change may affect their populations in the future.

A male Eurasian reed warbler (*Acrocephalus scirpaceus)* tagged with a light-level geolocator designed to record light intensity. Light data can be used to ascertain the time of local sunset and sunrise, subsequently allowing calculation of geographical position. These devices have recently revolutionised bird-migration science. | Photo by P. Procházka

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EVOLUTIONARY ECOLOGY

THERMAL ECOLOGY GROUP

Mechanisms behind climate change impacts on populations of cold-blooded animals

Climate change is a major factor affecting population dynamics, species interactions and the composition of ecological communities. The influence of climate change on geographic distribution and phenology has been convincingly demonstrated in many taxa.

However, how climate change impacts cold-blooded (ectothermic) organisms and how they buffer its influence remains unclear, despite intensive research in this area. Our results contributed to this issue with three unexpected findings.

1) Increasing body temperature, which would be expected under present climate change scenarios, does not affect the relationship between metabolic traits and, accordingly, the relative proportion of energy budget that could potentially be invested to somatic growth and reproduction.

2) Contrary to locomotor performance, locomotor activity may both increase and decrease with body temperature, which complicates predictions about the impact of climate change on species interactions and population dynamics.

3) An ectotherm's ability to seasonally adjust their phenotypes to changing thermal conditions (seasonal acclimation) shows high between--year variation. It is this high variance, and not mean value of acclimation response, that may act as an adaptive response to unpredictable seasonal shifts in environmental temperatures due to a changing climate. Our results demonstrate that the impacts of climate change on population dynamics and ectotherm responses to this challenge are more complicated than current theory predicts.

Larvae of the alpine newt (*Ichthyosaura alpestris*). | Photo by L. Gvoždík

Baškiera S, Gvoždík L (2019). Repeatability of thermal reaction norms for spontaneous locomotor activity in juvenile newts. *Journal of Thermal Biology*, **80**, 126-132.

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EVOLUTIONARY ECOLOGY

AVIAN EVOLUTIONARY ECOLOGY RESEARCH GROUP

Sexual selection, sperm size and speciation in passerine birds

We studied pre-mating and post-mating episodes of sexual selection in passerines. In a study comprising more than 200 species, we found that sexually promiscuous taxa show less male parental care, more short-term pair bonds, a greater degree of sexual dichromatism and more migratory behaviour. Male fertilisation success is, to some extent, determined by sperm size. We demonstrated tremendous variation in the size and shape of spermatozoa, not only across passerine species but also across individuals of the same population.

This variation has both environmental and genetic components. We applied quantitative genetic methods to reveal the degree to which sperm variation in the collared flycatcher (*Ficedula albicollis*) is genetic or environmental in origin, and found moderate levels of heritability and evolvability in total sperm length. We also assessed the role of sperm diversification in reproductive isolation for two hybridising nightingale species, and found that divergence in sperm morphology contributes to postcopulatory prezygotic isolation and is strengthened by reinforcement within the system.

In barn swallows, we studied how male sexual ornamentation (premating signal) and age (experience) affect male attractiveness and fertilisation success. Individual age was the key predictor positively associated with male extra-pair fertilisation success, irrespective of tail streamer length (a sexually selected trait in the European barn swallow subspecies (*Hirundo rustica*). We also demonstrated that in barn swallow subspecies with divergent sexual signals (tail streamers, melanin-based feather

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Janoušek V, Fischerová J, Mořkovský L, Reif J, Antczak M, **Albrecht T**, Reifová R (2019). Postcopulatory sexual selection reduces Z-linked genetic variation and might contribute to the large Z effect in passerine birds. *Heredity*, **122**, 622-635.

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Wang D, Forstmeier W, Valcu M, Dingemanse NJ, Bulla M, Both C, Duckworth RA, Kiere LM, Karell P, **Albrecht T**, Kempenaers B (2019). Scrutinizing assortative mating in birds. *PLoS Biology*, **17**, e3000156.

colouration), expression of the particular locally preferred sexual signal provides the most reliable information on the incidence and severity of parasite infections. To estimate costs associated with the development of sexual ornament, we developed a method to determine steroid hormone levels in extracts from feathers of small-bodied birds and revealed a negative association between stress hormone concentrations and the growth rates of tail feathers in European barn swallows.

It is often claimed that pair bonds preferentially form between individuals that resemble one another. Such assortative mating appears to be widespread throughout the animal kingdom. However, our meta-analysis of published estimates for assortative mating indicates that this apparent evidence vanishes gradually with increased control for confounding factors. As in other species that have been studied in detail, there appears to be no evidence for assortative mating by ornamentation (tail streamer length) in barn swallows.

The European barn swallow (*Hirundo rustica rustica*) male in his second calendar year of life. Ringed as a nestling one year before. | Photo by T. Albrecht

Each barn swallow individual is photographed. Here, the tail is spread to show white spots, one of many ornamental traits in European barn swallows. | Photo by O. Tomášek

Evolutionary ecology of tropical and temperate zone birds

We evaluated large-scale geographical patterns in life-histories and co-evolving physiological and behavioural traits (pace-of-life syndromes) across passerine birds (Passeriformes) in the temperate zone and tropics, with an emphasis on traits related to physiology and energetic metabolism, reproductive investment, sexual selection and survival. In addition, we also explored parasite-host relationships in the tropics.

We found that basal concentration of blood glucose, a major source of energy circulating in blood, is a key component of pace-of-life syndromes across passerine species, and that it co-evolves with species fecundity. Co-evolutionary processes that drive patterns of host--parasite associations can be deduced through congruence analysis of their phylogenies. We performed a co-speciation analysis of feather lice (genus Myrsidea and the Brueelia complex) and their avian hosts in the tropical rainforests of Cameroon.

Our analysis revealed a limited number of co--speciation events in both parasite groups and supported the importance of complex biotic interactions in tropical environments. We further investigated the effect of host colonisation of

new regions and the elevational distribution of host-parasite associations between birds and their vector-transmitted haemosporidian blood parasites in two geological and geographical settings, i.e. the mountains of New Guinea and the Canary Islands. Our results demonstrated that bird communities in younger regions had significantly lower levels of parasitism compared to those in older regions. We also estimated the effect of behavioural life-history traits (territoriality, social bonds and cooperative breeding) and environmental productivity on the occurrence of female solo song and duetting (separately) in songbirds of South Africa and Lesotho, regions characterised by a subtropical/tropical climate, a clear spatial environmental productivity gradient and detailed knowledge on avian species distribution and behavioural life-history traits.

Phylogenetically informed comparative analyses revealed that species with females producing only solo songs exhibited higher levels of territoriality than species with non-singing females but lower levels than duetting species. Further, female solo song and duetting are likely to be distinct song categories associated with different levels of territoriality.

The Red-faced Crimsonwing (*Cryptospiza reichenovii*) and its Myrsidea parasite. | From Gajdosova et al. 2020

The Pin-tailed whydah (*Vidua macroura*, left) and the Village indigobird (*Vidua chalybeata*, right) are obligate brood parasites distributed across sub-Saharan Africa. In the latter species, not only males but also females produce songs. | Photo by T. Albrecht

Bodawatta KH, Synek P, Bos N, Garcia-del-Rey E, Koane B, Marki PZ, **Albrecht T**, Lifjeld JT, Poulsen M, Munclinger P, Sam K, Jonsson KA (2020). Spatiotemporal patterns of avian host-parasite interactions in the face of biogeographical range expansions. *Molecular Ecology*, **29**, 2431-2448.

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EVOLUTIONARY ECOLOGY

BROOD PARASITISM RESEARCH GROUP

Video-cameras reveal hidden secrets in the life of the common cuckoo

A detailed knowledge of the biology of species is essential for understanding their life histories. One of the most effective tools for gaining insights into their lives is continuous video-recording. We used this methodology to capture hitherto undescribed behaviours in a study of interactions between the common cuckoo (*Cuculus canorus*) and the great reed warbler (*Acrocephalus arundinaceus*). While the cuckoo is the most studied brood parasite in the world, observations of actual parasitism events are rare because they occur over just a few seconds (Jelínek et al. 2021).

As almost every great reed warbler nest in our study area (South Moravia) was parasitised, we were able to record over 100 parasitism events. By recording each nest continuously for around seven days, we were able to observe behaviour that had never been recorded before. In addition, we noticed a very interesting behavioural pattern in some adult cuckoo females. Later in the breeding season, these females returned to the host nest and killed a cuckoo nestling by removing it from the nest and dropping it into the water below Interestingly, our Polish colleagues also recorded the same behaviour in Polish cuckoos, suggesting this was not simply a localised behaviour (Šulc et al. 2020a). Another recording showed that great reed warbler aggressiveness towards parasitising cuckoo females could prove lethal. Sometimes, the parasitising cuckoo was pushed out of the nest and into the water below, after which the host continued attacking the cuckoo female, the whole drama potentially ending with the cuckoo drowning in the water (Šulc et al. 2020b).

Video-cameras also revealed how difficult the life of cuckoo chicks can be in the host nest. Though they usurp all parental care for themselves and they are alone in the host nest, small warbler nests are not designed for such large and heavy chicks. Our recordings showed that smaller host nests sometimes disintegrated under the weight of the cuckoo chicks causing them to fall out of the nest, again potentially leading to the chicks' death (Honza et al. 2020).

Screenshots from our video showing a cuckoo female parasitising a great reed warbler nest and her quick exit from the nest with the host's egg in her beak. | Photo from Brood parasitism research group archive

Jelínek V, **Šulc M**, **Štětková G**, **Honza M** (2021). Fast and furious: host aggression modulates behaviour of brood parasites. *Ibis*.

Honza M, **Čapek M**, **Jelínek V**, **Šulc M** (2020). Falling out of the host nest: an overlooked factor decreasing survival of brood parasite chicks. *Journal of Avian Biology*, **51**, e02519.

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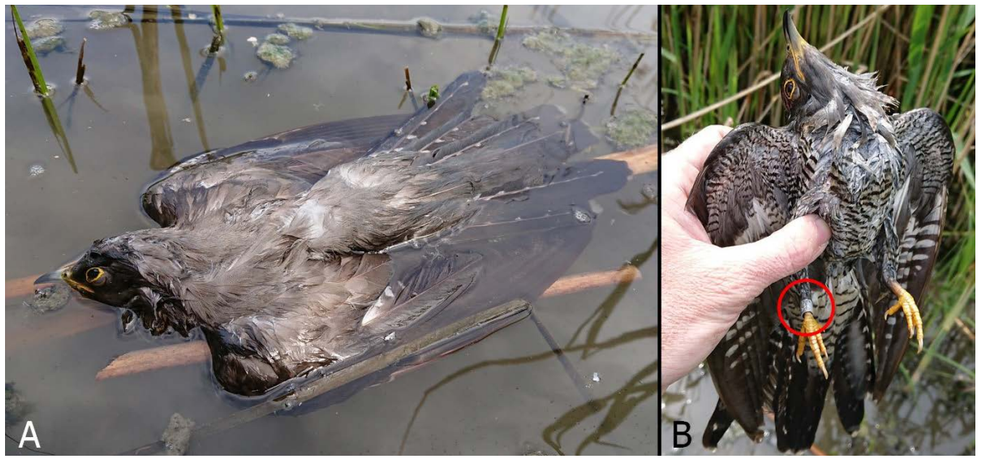
Šulc M, **Štětková G**, **Procházka P**, **Požgayová M**, **Sosnovcová K**, **Studecký J**, **Honza M** (2020). Caught on camera: circumstantial evidence for fatal mobbing of an avian brood parasite by a host. *Journal of Vertebrate Biology*, **69**, 20027.

Screenshots from our video showing killing behaviour of the adult cuckoo female. The cuckoo female landed on the reed warbler nest and immediately ejected the cuckoo chick out of the nest. | Photo from Brood parasitism research group archive



(A) Female cuckoo found dead in the water ca. 20 m from a great reed warbler nest on May 17, 2019. The cuckoo had several feathers plucked from her head but no other obvious wounds. (B) The cuckoo was ringed (ring no. GA 4235) as a nestling and reared by great reed warblers in June 2010 in the same fish rearing area. | Photo by P. Procházka

Screenshots from our video showing a cuckoo chick falling from a small reed warbler nest while both foster parents were present. | Photo from Brood parasitism research group archive

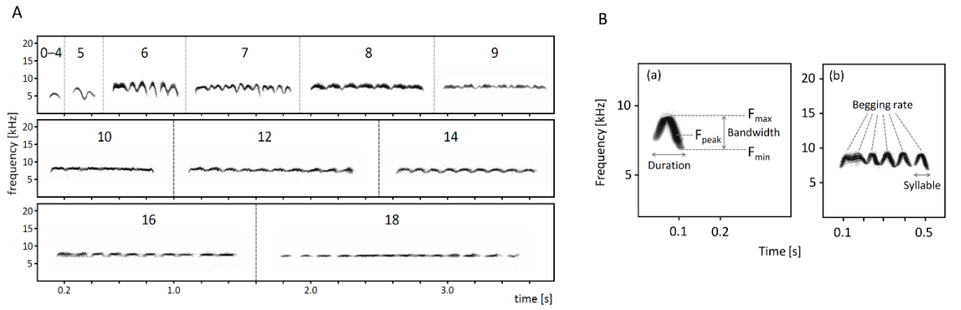
Uninvited intruder: The parasitic chick in the host nest

Begging is traditionally viewed as a highly dynamic and transformative component of parent-offspring communication. We examined whether parasitic cuckoo nestlings adjust their begging vocalisation according to foster species and explored age-dependent development dynamics of begging behaviour (Samaš et al. 2020). Using the reed warbler (*Acrocephalus scirpaceus*) and great reed warbler (*Acrocephalus arundinaceus*) as model species, we found that the begging call of host nestlings differed markedly between host species but not between cuckoos reared by the respective host species, suggesting that cuckoo chicks do not adjust begging vocalisation to host species but use generalised begging-call features to solicit food from the hosts.

We found that cuckoo begging-call parameters during ontogeny undergo rapid development, whereby the call frequency band narrows, syllable duration shortens and call rate tends to increase with increasing cuckoo age. Overall, our results emphasise how little we understand about parasite-host communication.

It is well known that virulent brood parasites such as the common cuckoo kill the host's progeny, which raises the question is rearing the parasite costlier for the host than rearing its own progeny? Surprisingly, this common assumption has not been comprehensively quantified in any host of any avian brood parasite.

Counterintuitively, rearing the parasitic cuckoo was not associated per se with overall higher physiological or physical costs to the two-host species studied (i.e. common redstarts (*Phoenicurus phoenicurus*;) and reed warblers) than the natural levels imposed by efforts to rear their own progeny. Indeed, some of the cost parameters were lower for the parasites than for hosts. This may, in part, explain the lower levels of counter-defence in these hosts.



(A) Sonograms for a typical common cuckoo begging sequence from the age of 0 days (day of hatching) until fledging at the age of 18 days, and (B) spectro-temporal characteristics of a begging sequence and a syllable used for analysis. | Fig. from Samaš et al. 2020

Samaš P, Žabková K, Petrusková T, **Procházka P**, **Požgayová M**, **Honza M** (2020). Nestlings of the common cuckoo do not mimic begging calls of two closely related *Acrocephalus* hosts. *Animal Behaviour*, **161,** 89-94.

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The redstart (*Phoenicurus phoenicurus*), a major cuckoo host in Karelia, Southern Finland | Photo by M. Honza

(A) The reed warbler (*Acrocephalus scirpaceus*), and (B) the Great Reed Warbler (*Acrocephalus arundinaceus*); major cuckoo hosts in Southern Moravia, Czech Republic | Photo by M. Honza

The pine forests of South Karelia (Southeast Finland) support healthy populations of redstarts. | Photo by P. Samaš

BIODIVERSITY

HOLOBIONT EVOLUTIONARY INTERACTIONS GROUP

Evolutionary history and diversity of selected parasites of African rodents

Rodents are the most diverse order of mammals in the world, and 17% of this diversity is found in Africa. We are using African rodents as a model to investigate historical and evolutionary patterns and processes in some groups of their parasites. In this context, we have shown that lung fungi from the genus *Pneumocystis* are common in African rodents, with several rodent species carrying more than one divergent *Pneumocystis* lineages/species.

The co-phylogenetic signal retrieved was highly significant and involved not only co-speciation events but also numerous sorting and two-host shift events. Our results are in contrast with a recent study showing a lack of specificity in *Pneumocystis* in the Rattini and Murini rodent tribes in Asia. We also used the model of Tigray hantavirus in Ethiopia to investigate its genetic diversity in two genetically related rodent species, *Stenocephalemys albipes* and *S. zimai*, occupying different elevational zones on the same mountain.

We discovered two divergent Tigray strains, implying that Tigray hantavirus may be found in other *Stenocephalemys* species than *albipes* and that its real diversity is likely to be much higher than currently thought.

Multimammate mice Mastomys natalensis are very abundant pests and virus reservoirs in a human-modified agricultural landscape in Tanzania | Photo by S. Gryseels

Petružela J, **Bryja J**, **Bryjová A**, Katakweba A, Sabuni C, **Baird SJE**, **Goüy de Bellocq J** (2019). Evolutionary history of *Pneumocystis* fungi in their African rodent hosts. Infection, *Genetics and Evolution*, **75**, 103934.

Meheretu Y, Stanley WT, Craig EW, **Goüy de Bellocq J**, **Bryja J**, Leirs H, Pahlmann M, Günther S (2019). Tigray orthohantavirus infects two related rodent species adapted to different elevations in Ethiopia. *Vector-Borne and Zoonotic Diseases*, **19**, 950-953.

Genetic diversity, specificity and epidemiology of *Mastomys*-borne mammarenaviruses

The Natal multimammate mouse, Mastomys natalensis, occurs throughout sub-Saharan Africa. Mitochondrial phylogenetics indicate that this rodent species became fragmented during the Pleistocene, forming six matrilineage phylogroups with distinct ranges, i.e. A-I, A-II, A-III, B-IV, B-V and B-VI. All except the A-III lineage were identified as natural reservoirs of mammarenaviruses, some members of which are highly pathogenic to humans.

We performed the first reported genomic characterisation of a new mammarenavirus in M. natalensis A-III in western Ethiopia, and proposed the name of Dhati Welel virus. Phylogenetic analysis indicated that the virus clusters with the Gairo virus found in *M. natalensis* B-IV in Tanzania. We also investigated mammarenavirus specificity to its host by screening 1,772 *M. natalensis* in a large area of Tanzania where three mitochondrial lineages meet (B-IV, B-V, B-VI).

We detected 52 positive individuals for one of three viruses, i.e. Gairo, Morogoro and Luna virus. Aside from three cases in one locality at the centre of the host hybrid zone, we confirmed the specificity of each mammarenavirus to a distinct host mitochondrial lineage. The Morogoro and Gairo viruses show significant differences in prevalence and genetic structure, with Gairo less structured than Morogoro.

Finally, using a seven-year capture-mark-recapture study in Tanzania and screening for the presence of antibodies against Morogoro virus, we investigated the degree to which Morogoro virus transmission changes with host population density and how the virus may be able to persist during periods of low host density.

The virus seroprevalence correlated positively with host density with a lag of 1-4 months, with seroprevalence dynamics possibly explained by a combination of both vertical and horizontal transmission, with a small number of animals needing to be infected chronically to ensure viral persistence.

Multimammate mouse. | Photo by S. Gryseels

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Feather microorganisms: hidden yet indispensable avian symbionts

People are fascinated with miscellaneous colour palette of bird´s feathers since ancient times. Yet, our knowledge of microbial feather symbionts and their roles in avian life-history is very limited to date. In our study, combining state-of-the-art metagenomics, we showed that the feather microbiome of free-living passerine birds is strongly species-specific, with host geographic origin playing a less important role.

Moreover, we provided the first evidence for antimicrobial peptide (bacteriocin)-producing bacterial communities inhabiting the feather integument and their impacts on host feather microbial diversity. These have the potential to mediate niche-competition and may be associated with functional species-specific feather microbiota.

In a second study, we investigated feather microbial load, diversity and community structure in two allopatric subspecies of Papua New Guinea white-shouldered fairywrens (*Malurus alboscapulatus*) varying in expression of melanin-based vs. structural plumage colouration.

We found that iridescent males had a lower feather microbial load, yet higher feather microbial diversity, than black matte and brown individuals. Moreover, iridescent males had distinct feather microbial communities compared to black matte and brown individuals. In conclusion, both studies were the first to indicate strong functional properties of the feather microbiome in birds, with a potential to affect immunity, overall fitness and, potentially, the evolution of physical colouration.

Banded wattle-eye (*Platysteira laticincta*): an endemic bird of Bamenda Highlands (Cameroon) with black iridescent feather wear. | Photo by V. Gvoždíková Javůrková

Gvoždíková Javůrková V, Kreisinger J, **Procházka P**, **Požgayová M**, Ševčíková K, **Brlík V**, Adamík P, Heneberg P, Porkert J (2019). Unveiled feather microcosm: feather microbiota of passerine birds is closely associated with host species identity and bacteriocin-producing bacteria. *The ISME Journal*, **13**, 2363-2376.

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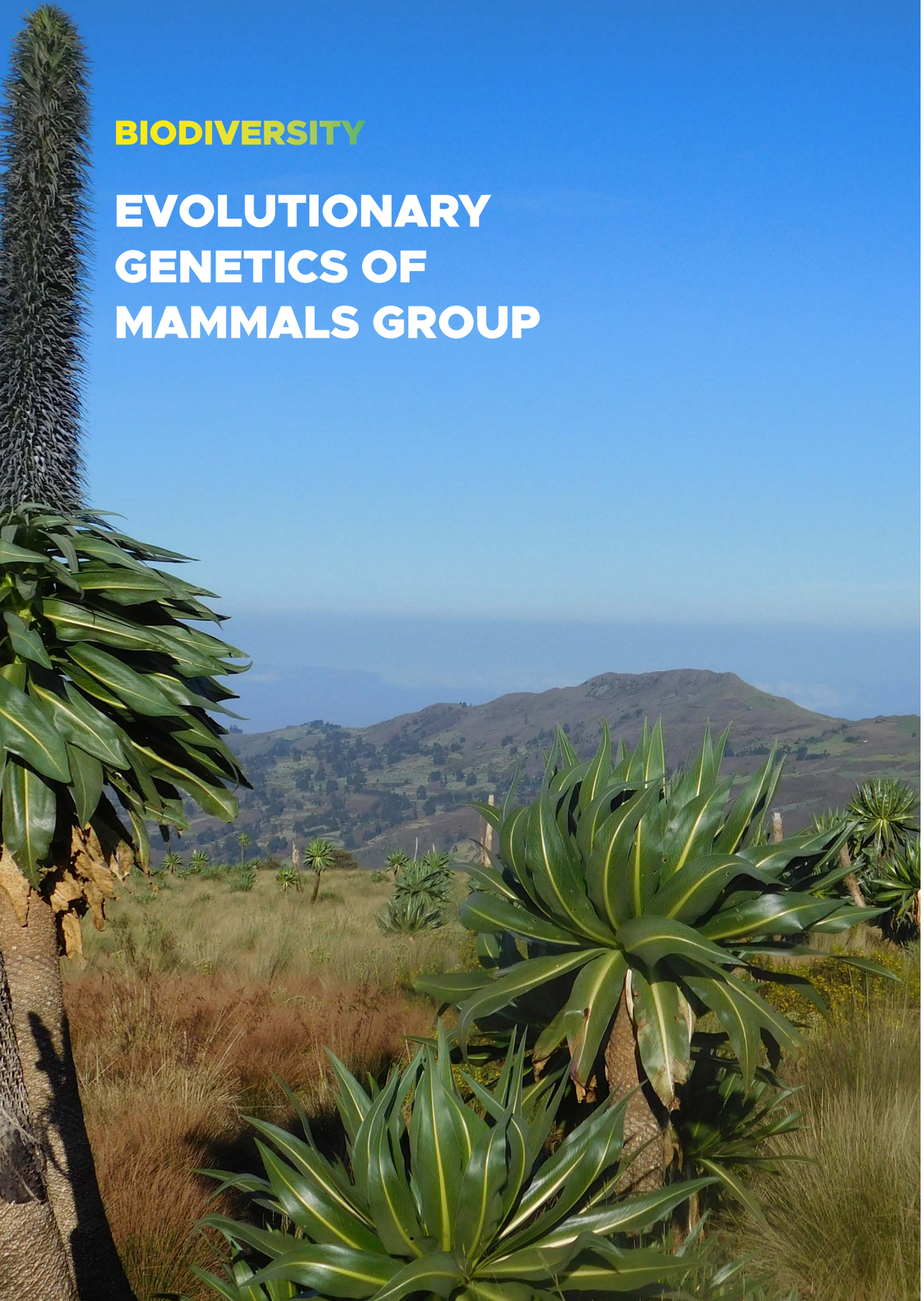
BIODIVERSITY

EVOLUTIONARY GENETICS OF MAMMALS GROUP



Unknown biodiversity and evolutionary processes in African rodents and shrews

There is no doubt that Africa is the continent with the least explored diversity of small mammals. At the same time, however, these groups (e.g. rodents and insectivores) are highly suitable models for the study of evolutionary processes that affect biodiversity and, as such, they are often used in speciation research.

The long-term activities of IVB researchers in sub-Saharan Africa have led to a unique collection of material that now enables range-wide phylo- and bio-geographic analyses and extensive integrated taxonomic revisions. In a series of phylogenetic / phylogeographic studies, evolutionary processes were assessed in detail in model taxa living in tropical forests, mountain ecosystems and savannas, often at a continental scale and the level of entire genera.

We found that, within genera, the origin of current diversity was primarily associated with climatic oscillations in the Plio-Pleistocene and (repeated) fragmentation of suitable habitats. To a much lesser extent, we identified speciation on an ecological / elevational gradient (mostly in the Ethiopian mountains) or significant fast morphological changes due to coexistence with humans (in the Sudanian savanna). Over 2019-2020, we completed and published comprehensive phylogenetic studies of species-rich and taxonomically complicated genera (*Arvicanthis*, *Acomys*, *Hylomyscus*, *Lemniscomys*, (Muridae, *Hylomyscus*) based on complete mitochondrial genomes and five nuclear genes reveals their evolutionary history and undescribed diversity. *Molecular Phylogenetics and Evolution*, **144**, 106703.

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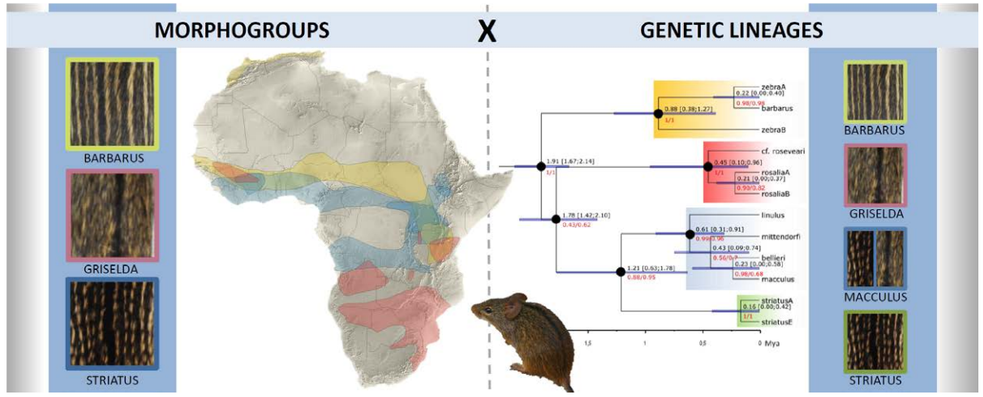
Stenocephalemys) or important intra-generic clades (in *Mus*, *Praomys* or *Lophuromys*), including an analysis of the main evolutionary mechanisms leading to successful radiation of these rodents in sub-Saharan Africa.

Last, but not least, integrated taxonomic work based on a combination of genetic, morphological and ecological approaches led to the discovery and formal description of eight new African mammal species.



African striped grass mice (genus *Lemniscomys*) have a highly conspicuous dorsal pelage colouration, with one or multiple black stripes. Phylogenomic analysis of the whole genus at a pan-African geographic scale showed that the type of dorsal colouration only partly reflected evolutionary relationships among delimited species. On the other hand, phylogenetic groups were well associated with the main biogeographical regions of sub-Saharan Africa.

Montane forests in southern Ethiopia harbour unique and highly endemic fauna and flora. | Photo by J. Bryja

Ethiopia – a unique centre of mammalian diversity and endemism

Biological diversity is non-uniformly distributed in sub-Saharan Africa. Over the last decade, IVB researchers have intensively studied numerous aspects of mammalian diversity, especially in Ethiopia, which we confirmed as an area with a very high and endemic biodiversity. In close collaboration with Ethiopian, Russian and North American researchers, many regions were explored and the material collected analysed using integrative approaches, including geometric morphometry, genomics and pathogen screening.

Available data on the occurrence of 104 Ethiopian rodent species were summarised in the form of a monograph with an annotated list of genetically identified species, distribution maps and a biogeographical summary. Individual accounts for the 104 species comprised a map and a short annotation, including brief taxonomic and distributional details. In total, we documented 40 genera and 10 families and, based on their distribution patterns, we were able to define eight biogeographical Ethiopian rodent categories.

Of these, Ethiopian endemics, which represent the highest proportion of rodent diversity (43 of 104 species; 41.3 %), were mostly recorded in the Highlands, while 27 species were recorded as living in the Somali-Masai and 13 species in the Sudanian savanna. Detailed genetic studies of numerous taxa showed that the Ethiopian Highlands are a highly suitable habitat for studies of speciation processes as classical allopatric speciation is often supplemented by strong ecological divergences along an elevational gradient.

Studies of small mammal genetic diversity also made it possible to identify unique areas of endemism in need of urgent protection, data that we were then able to pass on to the relevant conservation authorities.

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Konečný A, Hutterer R, Meheretu Y, **Bryja J** (2020). Two new species of *Crocidura* (Mammalia: Soricidae) from Ethiopia and updates on the Ethiopian shrew fauna. *Journal of Vertebrate Biology*, **69**, 20064.

Mizerovská D, **Mikula O**, Meheretu Y, **Bartáková V**, **Bryjová A**, Kostin DS, Šumbera R, Lavrenchenko LA, **Bryja J** (2020). Integrative taxonomic revision of the Ethiopian endemic rodent genus *Stenocephalemys* (Muridae: Murinae: Praomyini) with the description of two new species. *Journal of Vertebrate Biology*, **69**, 20031.

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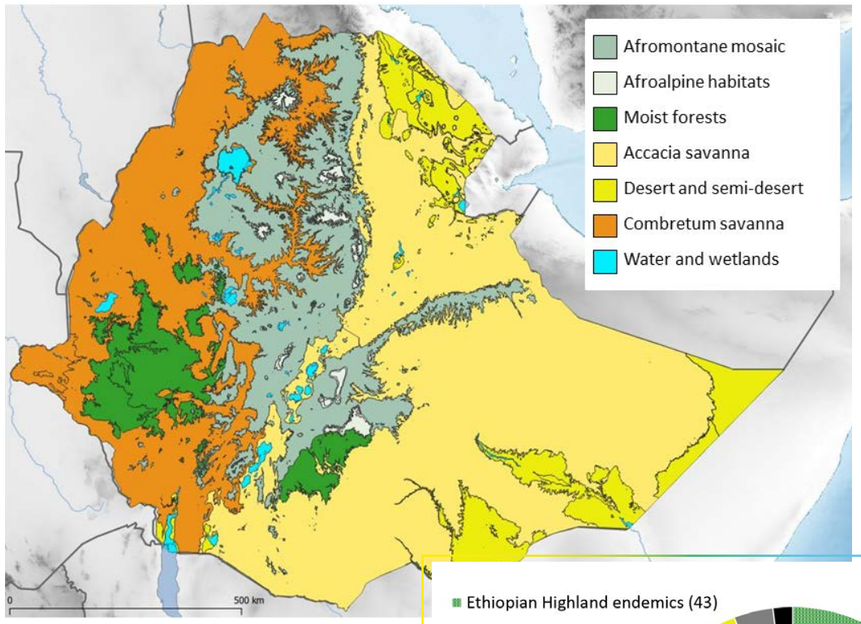
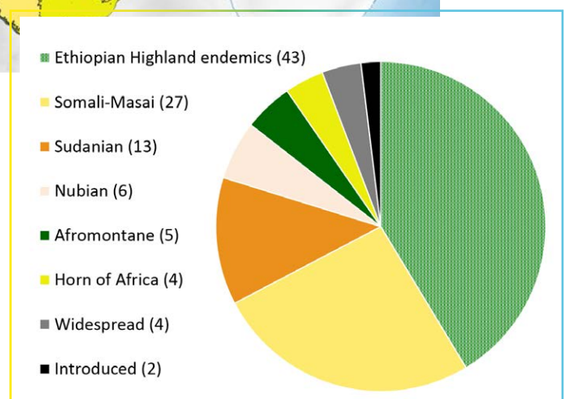
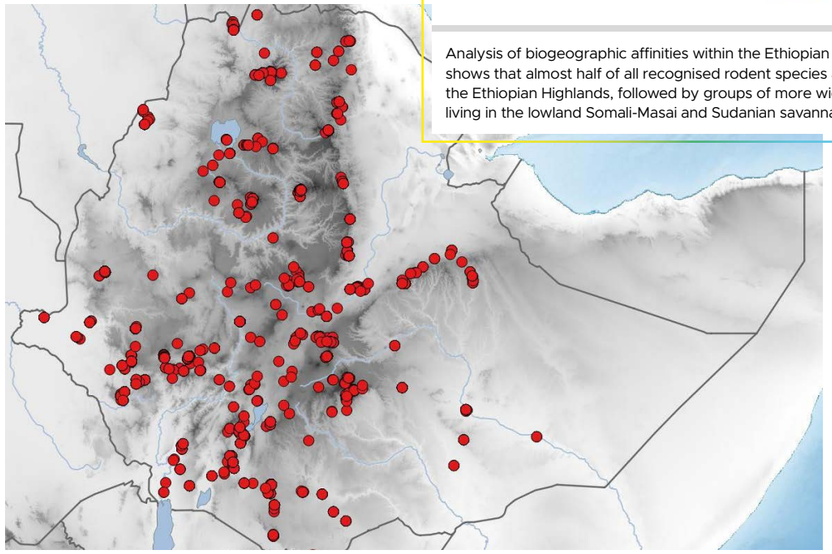


Distribution of potential major natural vegetation types in Ethiopia. High biodiversity in Ethiopia is, to a large extent, caused by the mosaic of three major African sub-Saharan biogeographical regions: the Ethiopian Highlands (grey, white and green), the Sudanian region (orange) and the Somali-Masai region (yellow).



Analysis of biogeographic affinities within the Ethiopian rodent fauna shows that almost half of all recognised rodent species are endemic to the Ethiopian Highlands, followed by groups of more widespread species living in the lowland Somali-Masai and Sudanian savannahs.

Distribution of localities with recent rodent data collected and genotyped within Ethio-Czech expeditions and the Joint Ethio-Russian Biological Expedition.



BIODIVERSITY

HERPETOLOGICAL DIVERSITY GROUP

Amphibians and reptiles of tropical Africa

Tropical montane and lowland rainforests are amongst those areas with the greatest diversity and endemism of organisms. In our work, we focus on amphibians and reptiles within these ecosystems. We investigated the evolutionary history of puddle frogs (*Phrynobatrachus*) inhabiting the Cameroon Highlands, on the intersection between Central and West Africa, using an integrative approach combining genetic, morphological and bioacoustic traits.

The study included formal descriptions of two newly discovered species to science, the Hidden Puddle Frog (*P. arcanus*) and the Tchabal Mbabo Puddle Frog (*P. mbabo*), both critically endangered. We also studied the diversification history of the African foam-nest treefrog (*Chiromantis rufescens*) in lowland rainforests, a model species widespread across the Guineo-Congolian rainforest.

Furthermore, through analysis of ca. 500 frog samples from Cameroon and northern Congo, we contributed to an improved understanding of the distribution of the fungal amphibian pathogen *Batrachochytrium dendrobatidis* in Africa. We also assessed the systematic position of the mysterious clawed frog *Xenopus fraseri* using state-of-the-art DNA sequencing and osteological techniques. Last, but not least, new data on the Speke's tortoise (*Kinixys spekii*) indicated an important distribution extension for this little-known and rare land tortoise from the savannas of south-eastern Africa.

A juvenile Hidden Puddle Frog (*Phrynobatrachus arcanus*) from Mt. Gangirwal on the Cameroon-Nigeria border. | Photo by V. Gvoždík

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Isolated populations of reptiles and amphibians in the Czech Republic

Using genetic methods and field data, we studied various geographically isolated populations of rare Czech reptiles and amphibians. One study focused on the origin of three isolated populations of the common wall lizard (*Podarcis muralis*), located on the north-eastern margin of the species' range. Analysis of mitochondrial DNA in a phylogeographical framework showed that the Czech populations are a continuation of the closest populations from Slovakia; thus, the Czech populations are either native (at least one, the oldest population) or were established by transfer from the nearest Slovak populations. Consequently, we recommend the conservation of these populations.

As part of our herpetological field research, we discovered two new populations of the natterjack toad (*Epidalea calamita*) in Czech Silesia (north-eastern part of the Czech Republic). The natterjack toad is the most endangered Czech anuran amphibian and was previously only known from Bohemia (western part of the Czech Republic).

These newly discovered Czech Silesian populations are linked to populations in Poland. Both only occur in a small area where their natural habitat is highly threatened; hence, appropriate conservation actions are urgently needed to protect these unique and endangered populations.

A female Natterjack Toad (*Epidalea calamita*) from Krnov, Czech Silesia. | Photo by V. Gvoždík

Jablonski D, **Gvoždík V**, Choleva L, Jandzik D, Moravec J, Mačát Z, Veselý M (2019). Tracing the maternal origin of the common wall lizard (*Podarcis muralis*) on the northern range margin in Central Europe. *Mitochondrion*, **46**, 149-157.

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Conservation potential of overlooked non-farmed habitats for farmland biodiversity

Agricultural intensification has led to landscape simplification which has resulted in a massive loss of farmland biodiversity, partially due to a huge reduction in the area of non-farmed habitat. The results of our studies have shown that manure heaps and non-cropped patches under power line infrastructure can represent crucial, though usually overlooked, habitats for many declining species in the agricultural landscape.

In particular, we demonstrated that farmland manure heaps represent important year-round habitats for birds (including farmland specialists and species of conservation concern), especially due to the high abundance and availability of nutrient-rich food resources (e.g. invertebrate prey and undigested grains and seeds) during critical periods for farmland birds. As such, the number of manure heap stands in farmland may be a good proxy for the presence of high-quality foraging habitats essential for declining farmland specialist birds.

Similarly, we also found that power-line infrastructure can provide important refugia for small mammals in farmland ecosystems, not least as they provide suitable and persistent habitats for overwintering and spring dispersal. To conclude, our studies have shown that various overlooked non-farmed habitats have high potential for the conservation of farmland biodiversity and increased current knowledge regarding the important role that non-farmed habitat can play in protecting farmland biodiversity.

Electricity pylons are overlooked refuges for small mammals in agricultural landscapes. | Photo by M. Šálek

The conservation potential of manure heaps has been underestimated. | Photo by M. Šálek

Lapwing is a flagship species of agricultural landscape. | Photo by M. Šálek

Šálek M, Václav R, Sedláček F (2020). Uncropped habitats under power pylons are overlooked refuges for small mammals in agricultural landscapes. *Agriculture, Ecosystems and Environment*, **290**, 106777.

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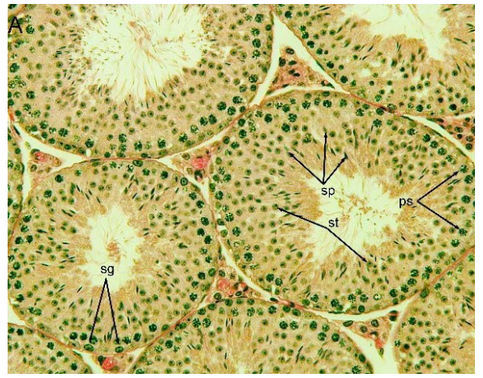
BIODIVERSITY

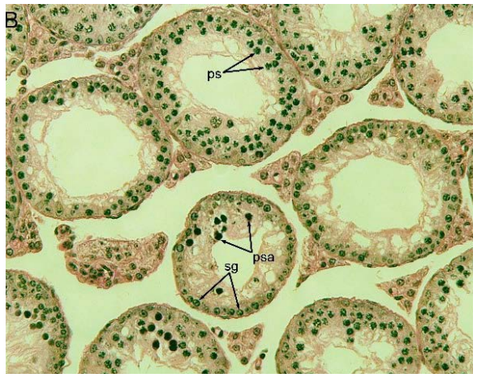
HOUSE MOUSE RESEARCH GROUP

Evolution of reproductive isolation barriers in the house mouse

The classical definition posits hybrid sterility as a phenomenon where two parental taxa, each of which is fertile, produce a hybrid that is sterile. The hybrid sterility gene in vertebrates, Prdm9, codes for a histone methyltransferase and was first identified in crosses between two laboratory mouse strains derived from *Mus mus musculus* and *M. m. domesticus* subspecies. However, the role of this sterility gene as a reproductive barrier component outside of the laboratory model remained unclear. We showed that Prdm9 allelic incompatibilities represent the primary cause of meiotic arrest and infertility in intersubspecific hybrids between *M. mus musculus* and *M. m. domesticus*, including 16 wild-derived strains kept in a house mouse breeding facility in Studenec. Our data show for the first time that male infertility in wild-derived *musculus* and *domesticus* subspecies F1 hybrids is controlled by Prdm9 as the major hybrid sterility gene. On the other hand, introgression of the musculus Y chromosome on *domesticus* background resulted in increased sperm quality and quantity, along with fighting ability, in such males. Interestingly, introgression of the *domesticus* Y chromosome on musculus background had negative effects on the observed traits. Such bipolar advantages depending conditionally on the direction of Y introgression could facilitate the spread of the *musculus* Y chromosome across the house mouse hybrid zone, and at the same time explain why the Y introgression is strictly unidirectional. Contrary to sterility genes, the Y chromosome can be viewed as an antispeciation element.



Fertile male with normal spermatogenesis with all stages visible – spermatogonia (sg), primary spermatocytes (ps), spermatids (st) and sperm (sp). Seminiferous tubules are full of sperm tails. | Photo by L. Ďureje



Sterile male with spermatogenesis broken at the first meiotic division and primary spermatocytes (ps) enter apoptosis (psa). Lumen of seminiferous tubules is empty. | Photo by L. Ďureje

Mukaj A, **Piálek J**, Fotopulosová V, Morgan A, Odenthal-Hesse L, Parvanov E, Forejt J (2020). Prdm9 Intersubspecific Interactions in Hybrid Male Sterility of House Mouse. *Molecular Biology and Evolution*, 37, 3423-3438.

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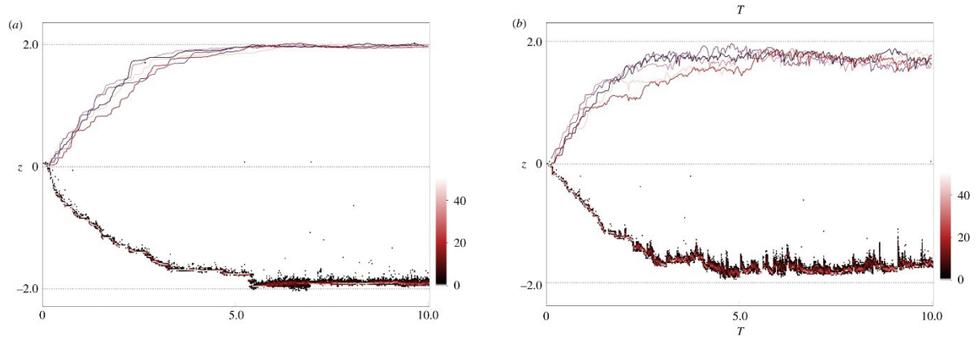
BIODIVERSITY

BIOINFORMATICS GROUP

Speciation and Hybrid Zones

We pick out a recent collaborative publication as an illustration of our work.

The conditions under which speciation occurs are at the core of evolutionary biology. A series of recent popular models of speciation had been developed without due regard to a central tenet of genetics, i.e. that the mutation process is undirected. In this study we were able to demonstrate that this neglect has led to overestimation of the power of diversifying selection to create 'biological' species. Rather, it creates 'Mallet' species, i.e. units that can maintain their distinctiveness in the face of ongoing gene flow.



The mean phenotype through time for five simulation replicates (top half of each graph) and the evolution of individual trait values z for a single run (bottom half) for 10 × 2N_e generations for the 'strong–rare' scenario. The local optimum is represented by the dotted line (ϑ_- = −2 and ϑ_+ = 2). (a) Without GBMs. (b) With GBMs (U_g/U_l = 2 and U = 5 × 10^{-5}). The bottom half of each panel shows the distribution of phenotypes in 100 individuals (sampled every 500 generations). The shade of each dot represents the number of individuals per bin (see colour bar). | Fig. from Bisschop et al. 2020

Bisschop G, Setter D, Rafajlović M, **Baird SJE**, Lohse K (2020). The impact of global selection on local adaptation and reproductive isolation. *Philosophical Transactions of the Royal Society B-Biological Sciences*, **375**, 20190531.

BIODIVERSITY

CONSERVATION BIOLOGY GROUP

Factors threatening large carnivores in the Czech Republic

A number of factors have caused large carnivores, and especially the Eurasian lynx (*Lynx lynx*), to become highly endangered, with landscape fragmentation and direct human persecution through illegal hunting the most important. A sociological study within the hunting community and students of secondary forestry schools and forestry universities showed that the attitude of these stakeholders to the Eurasian lynx is more negative than that of the general public.

Moreover, within an anonymous survey, up to 10 % of hunters admitted to shooting one or more lynx illegally due to direct competition for ungulates and the opportunity to obtain a valuable trophy. A study focusing on the conservation genetics of lynx on the edge of the Western Carpathians examined the impact of such poaching, together with partial population isolation due to landscape fragmentation.

The results confirmed that, though lynx population in the area along the border with Slovakia is connected to the rest of the West-Carpathian population, gene flow is strictly limited, meaning that high natal philopatry of offspring (due to high turnover of resident lynx effected by poaching and traffic mortality) leads to mating with close relatives, which has decreased genetic variability and effective population size of the population on the western edge of Carpathian lynx distribution.

Lynx Laura died in October 2017 as a result of a gunshot wound to the hind limb. At the time of the incident, she was leading two cubs, which probably also died without her. | Photo by M. Bojda

Lynx Ivonka died in April 2017 as a result of a collision with a train. During her life she became the mother of at least 9 kittens, one of which (Kryštof lynx) traveled to the Moravian Karst. | Photo by F. Jaskula

Červený J, **Krojerová-Prokešová J**, Kušta T, **Koubek P** (2019). The change in the attitudes of Czech hunters towards Eurasian lynx: Is poaching restricting lynx population growth? *Journal for Nature Conservation*, **47**, 28-37.

Krojerová-Prokešová J, **Turbaková B**, Jelenčič M, Bojda M, Kutal M, Skrbinšek T, **Koubek P**, **Bryja J** (2019). Genetic constraints of population expansion of the Carpathian lynx at the western edge of its native distribution range in Central Europe. *Heredity*, **122**, 785-799.

PARASITES AND DISEASES

FISH ECOLOGY GROUP

Parasites co-introduced with their fish hosts to Europe

Non-native parasites are often co-introduced to new habitats together with their hosts. In this new habitat, many non-native parasite species only infect their original non-native host, while others may infect native hosts, thereby reinforcing the parasite's range expansion. Based on the model of freshwater fish species introduced into Europe, we examined presence and distribution of co-introduced parasites and assessed their potential risk for local fish fauna.

Monogenean parasites infecting the gills, fins and fish body surface are the most frequent group of co-introduced parasite species and are primarily found on centrarchid and ictalurid fish originating from North America, and in gobiid fish originating from the Ponto-Caspian region. While co-introduced monogenean and trematode species appear specific to their original hosts, and therefore represent a low risk for switching to local fish species, the North-American cestode *Proteocephalus ambloplitis* can potentially use native European fishes as their second intermediate hosts.

Our intensive investigation of co-introduced parasites in their non-native ranges led to the description of a new gyrodactylid species (originating from North America), the description of a new trichodinid parasite found in two distant populations of pumpkinseed sunfish (*Lepomis gibbosus*) and to the morphological characterisation of the reproductive organs of an ancyrocephalid monogenean. Our data indicate that co-introduced parasite fauna are more diverse than originally suspected.

Microphotograph of the plerocercoid scolex of *Proteocephalus ambloplitis* (Cestoda) ex *Lepomis gibbosus* (Centrarchidae) from Bègles Plage, France; originally distributed in North America and recently introduced to Europe. | Photo by M. Ondráčková

Ondračková M, Seifertová M, **Bryjová A**, Leis E, **Jurajda P** (2020). Morphometric and genetic evidence for cryptic diversity of *Gyrodactylus nebulosus* (Monogenea) in non-native European populations of *Ameiurus nebulosus* and *A. melas*. *Parasitology*, **147**, 1700-1711.

Ondračková M, **Pravdová M**, Seifertová M, Přikrylová I, **Kvach Y**, Ribeiro F (2020). *Onchocleidus principalis* (Monogenea: Ancyrocephalidae) co-introduced to Europe with centrarchid fish. *Acta Parasitologica*, **65**, 974-979.

Kvach Y, Seifertová M, Carassou L, **Ondračková M** (2020). First record of the American cestode *Proteocephalus ambloplitis* (Leidy, 1887) (Proteocephalidae) in Europe. *Journal of Helminthology*, **94**, e144.

Kvach Y, **Ondračková M** (2020). Checklist of parasites for Ponto-Caspian gobies (Actinopterygii: Gobiidae) in their native and non-native ranges. *Journal of Applied Ichthyology*, **36**, 472-500.

Ondračková M, **Kvach Y**, Martens A, **Jurajda** P (2019). Limited parasite acquisition by non-native *Lepomis gibbosus* (Actinopterygii: Centrarchidae) at two ponds in the Upper Rhine basin, Germany. *Journal of Helminthology*, **93**, 453-460.

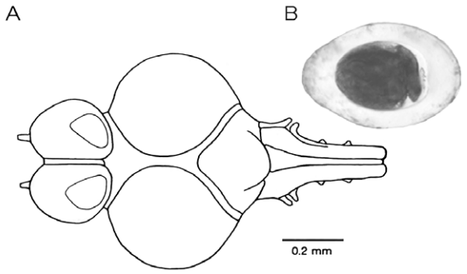
Yuryshynets V, **Ondračková M**, **Kvach Y**, Masson G (2019). Trichodinid ectoparasites (Ciliophora: *Peritrichia*) of non-native pumpkinseed (*Lepomis gibbosus*) in Europe. *Acta Protozoologica*, **58**, 69-79.

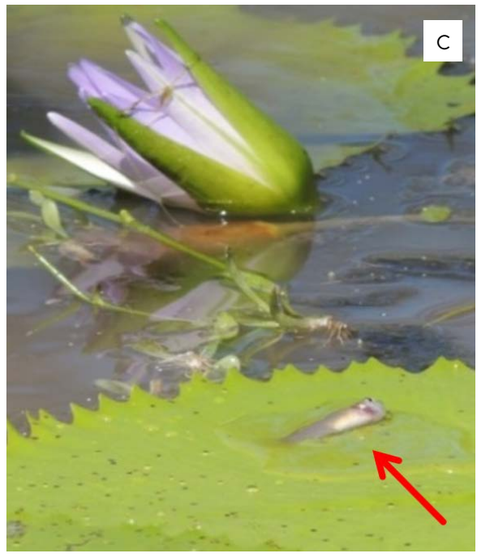
Parasites that affect the behaviour and reproduction success of the fish host

Parasites with complex life cycles often alter the physiology, morphology or behaviour of their intermediate hosts, facilitating the completion of their life cycle. As a side-effect of the infection, both body condition and reproduction can be negatively affected, with consequences on host population dynamics in parasite-affected environments. Aquatic habitats offer ideal conditions for the maintenance and evolution of parasite life cycles, with fishes frequently utilised as hosts by the parasitic organism.

Using fish as parasite intermediate hosts, we assessed the effect of larval trematodes (metacercariae) on fish behaviour and reproductive traits. African killifish (*Nothobranchius furzeri*) infected with metacercariae of *Apatemon* sp. showed conspicuous risky behaviour under both natural and experimental conditions. Infected fish spent most of the time near the water's surface and displayed conspicuous swimming behaviour that included jumps, uncoordinated movements and rotations after simulated attack. Metacercariae of *Apatemon* sp. are relatively large parasites located exclusively in the killifish cranial cavity and even a low intensity of infection can affect host behaviour. The observed behaviour patterns greatly facilitate location and predation of infected hosts by avian definitive hosts. It is possible that the extremely short lifespan of killifish may have played a significant role in the evolution of behavioural manipulation.

In comparison, the effects of chronic eye fluke infection caused by metacercariae of *Diplostomum pseudospathaceum* on reproduction of European bitterling (*Rhodeus amarus*) is only limited. While parasite infection slightly reduced sexual ornamentation in males, behavioural observations failed to identify any difference in reproductive activity between infected and control fish. On the other hand, there was an almost two-week delay in the peak of female ovulation and offspring production in infected fish, which is known to coincide with higher juvenile mortality. Despite the phylogenetic relatedness of both parasite species (Superfamily Diplostomoidea), the effect of infection on the fish intermediate host differed greatly, highlighting the wide spectrum of direct effects and side effects of parasites on their hosts.





Schematic representation of the relative proportions of (**A**) the fish host's (*Nothobranchius furzeri*) brain and (**B**) metacercaria of *Apatemon* sp. located in the cranial cavity of an infected fish (both figures to equal scaley). (**C**) An African killifish stranded on a floating water lily pad after disruption. | Photos by R. Blažek and V. Nezhybová

Nezhybová V, **Reichard M**, Methling C, **Ondračková M** (2020). Limited impacts of chronic eye fluke infection on the reproductive success of a fish host. *Biological Journal of the Linnean Society*, **129**, 334-346.

Nezhybová V, **Janáč M**, **Reichard M**, **Ondračková M** (2020). Risk-taking behaviour in African killifish – a case of parasitic manipulation? *Journal of Vertebrate Biology*, 69, 20022.

Invasive gobies in Czech rivers

Following its arrival in the Czech Republic (Morava 2008; Elbe 2015), the invasive round goby (*Neogobius melanostomus*) has rapidly come to dominate local fish assemblages. Biological invasions, along with habitat loss and climate change, pose a real threat to native species; however, impact predictions are hampered by inadequate knowledge of how these factors interact. As part of our long-term monitoring efforts, we examined how round goby interacts with native fauna and what impacts climate change may have on native and non-native species.

A) Banks of the River Dyje in 2011, with rip-rap clearly visible; B) banks of the River Dyje in 2017, with rip-rap covered in a thick layer of sediment and aquatic/riparian vegetation. | Photos by L. Šlapanský

Regarding dispersal, we found that while established goby populations remain relatively stationary, with just a few individuals undertaking long-distance upstream dispersal, release of many propagules results in appreciably greater movement rates. In general, smaller, mostly male, fish tended to move further and appear first in uninvaded areas (Šlapanský et al. 2020).

We also investigated whether round goby invasion has affected the pattern of total mercury transfer through multiple trophic levels in the rivers Dyje and Elbe. We observed similar bioaccumulation patterns in both rivers, with no significant difference between round goby and a native benthic species with a similar trophic niche. Further, predatory species had relatively low biomagnification factors due to their omnivorous diets. As such, we found no evidence for changes in trophic contaminant transfer or any increased threat from bioaccumulation (Jurajda et al. 2020).

Local-scale climate change impacts along the River Dyje (increased temperature, reduced rainfall, shifts in peak rainfall) have impacted the river's hydrology (reduced flow, reduction in flood events, increased siltation, macrophyte growth), allowing native fish species to recolonise the banksides and reducing round goby density due to the loss of its preferred rip-rap habitat. While most studies predict long-term negative impacts on fish populations, our study suggests that local-scale impacts will be more complex, resulting in short-term positive and negative effects. Identification of these positive effects will be essential in clarifying long-range forecasts and identifying management procedures (Roche et al. 2020).

Šlapanský L, **Janáč M**, **Roche K**, **Jurajda P** (2020). Round goby movement patterns in a non-navigable river. *Canadian Journal of Fisheries and Aquatic Sciences*, **77**, 475–483.

Jurajda P, **Všetičková L**, Švecová H, Kolářová J, **Jurajdová Z**, **Janáč M**, **Roche K** (2020). Trophic mercury biomagnification patterns in two European rivers following introduction of invasive round gobies (*Neogobius melanostomus*). *Limnologica*, **84**, 125817.

Roche K, **Jurajda P**, **Šlapanský L**, White SM (2020). Turning back the tide? Local-scale impacts of climate change may have positive effects by restoring natural riverine habitat and reducing invasive fish density. *Freshwater Biology*, **65**, 2010–2020.

PARASITES AND DISEASES

PRIMATE SYMBIONT ECOLOGY GROUP

Gut microbiome adaptations of nonhuman primates

Our research group undertakes long-term research on gastrointestinal symbionts of western lowland gorillas, central African chimpanzees and humans co-habiting in the forest ecosystem of the Dzanga Sangha Protected Areas (DSPA) in the Central African Republic. In two recent studies, we focused on intestinal trichomonads and the bacterial element of the microbiome.

We detected tetratrichomonads from 'novel lineage 2' in DSPA chimpanzees, a lineage previously reported mostly in captive and wild chimpanzees. In DSPA gorillas, we found two different genotypes of *Tetratrichomonas*, the more frequent genotype being identical with that found previously in wild western lowland gorillas from Cameroon, while sequences from the second genotype was almost identical to those previously obtained from an anorexic French woman.

We provided the first report of intestinal tetratrichomonads in asymptomatic, apparently healthy humans. These human tetratrichomonads are members of a lineage that has previously been reported in domestic and wild pigs and a domestic horse. Our findings suggest that ecology and spatial overlap of hominids in this tropical forest ecosystem has not resulted in exchange of intestinal trichomonads between the hosts.

Compared with urban-industrial populations, small-scale human communities worldwide share a significant number of gut bacterial microbiome traits with nonhuman primates. We profiled the faecal metagenomes of BaAka hunter-gatherers and traditional Bantu agriculturalists in the DSPA and compared them with those of a sympatric western lowland gorilla group across two seasons of variable dietary intake.

Parallel microbiome traits were observed between hunter-gatherers and gorillas when the latter consumed more structural polysaccharides during dry seasons, while small-scale agriculturalist and gorilla microbiomes showed significant functional overlap when gorillas consumed more seasonal ripe fruit during wet seasons. Notably, dominance of microbial transporters, transduction systems and gut xenobiotic metabolism was observed in association with traditional agriculture and energy--dense diets in gorillas at the expense of a functional microbiome repertoire capable of metabolising more complex polysaccharides.

Our results show conserved functional gut microbiome adaptations to analogous diets in small-scale human populations and non-human primates, highlighting the role of plant dietary polysaccharides and diverse environmental exposures in this convergence.

Petrželková KJ, Smejkalová P, Céza V, **Pafčo B**, Shutt-Phillips KA, Todd A, Jirků-Pomajbíková K, Benavides J, Modrý D, Čepička I (2020). Sympatric western lowland gorillas, central chimpanzees, and humans are infected with different trichomonads. *Parasitology,* **147**, 225-230.

Sharma AK, **Petrželková KJ**, **Pafčo B**, Robinson CAJ, Fuh T, Wilson BA, Stumpf RM, Torralba MG, Blekhman R, White B, Nelson KE, Leigh SR, Gomez A (2020). Traditional human populations and nonhuman primates show parallel gut microbiome adaptations to analogous ecological conditions. *mSystems*, **5**, e00815-20.

The composition of food affects microbiome of non-human primates and humans. Especially plant dietary polysaccharides play an important role. | Photo by L Vit

Left - BaAka's children eat so-called gozo, prepared from cassava tubers
Right- typical food of Dzanga Sangha tribes - gozo (cassava) and chopped koko (*Gnetum africanum*) leaves. | Photo by CJ Robinson

PARASITES AND DISEASES

BAT RESEARCH GROUP

Hibernation and health status of bats

Hibernation is an adaptation of temperate zone bats that allows them to survive scarcity of alimentary resources in winter. With lowered body temperature, the animal's metabolic and immunological functions are suppressed (Heger et al. 2020, Pikula et al. 2020) which, together with lowered energetic costs for thermoregulation, makes hibernation a behavioural adaptation of energy metabolism. While species-specific hibernation behaviour is known, this appears to remain stable over time, despite climate change and increasing populations (Blažek et al. 2019, Martínková et al. 2020).

Pathogen exposure during hibernation shapes the survival and subsequent reproductive success of organisms directly, by draining the host of resources, and indirectly, by contributing to pathogen transmission. To minimise the impact of parasites and pathogens, hosts can alter their behaviour to select environmental conditions limiting pathogen growth (Martínková et al. 2019) or evolve molecular mechanisms enabling the host to tolerate the infection (Davy et al. 2020).

Different species of bat react in different ways to infection, with some triggering a systemic

Banďouchová H, **Zukal J**, Linhart P, **Berková H**, Brichta J, Kováčová V, Kubíčková A, Abdelsalam EEE, Bartonička T, **Zajíčková R**, Pikula J (2020). Low seasonal variation in greater mouse-eared bat (*Myotis myotis*) blood parameters. *PLoS ONE*, **15**, e0234784.

Blažek J, **Zukal J**, Banďouchová H, **Berková H**, Kováčová V, **Martínková N**, Pikula J, Řehák Z, Škrabánek P, Bartonička T (2019). Numerous cold arousals and rare arousal cascades as a hibernation strategy in European *Myotis* bats. *Journal of Thermal Biology*, **82**, 150-156.

Davy CM, Donaldson ME, Banďouchová H, Breit AM, Dorville NAS, Dzal YA, Kováčová V, Kunkel EL, **Martínková N**, Norquay KJO, Paterson JE, **Zukal J**, Pikula J, Willis CKR, Kyle CJ (2020). Transcriptional host-pathogen responses of *Pseudogymnoascus destructans* and three species of bats with white-nose syndrome. *Virulence*, **11**, 781-794.

Heger T, **Zukal J**, Seidlová V, Němcová M, Nečas D, Papežíková I, Piaček V, **Zajíčková R**, Banďouchová H, Pikula J (2020). Measurement of phagocyte activity in heterotherms. *Acta veterinaria Brno*, **89**, 79-87.

Linhart P, Banďouchová H, **Zukal J**, Votýpka J, Kokurewicz T, Dundarova H, Apoznanski G, Heger T, Kubíčková A, Němcová M, Piaček V, Sedláčková J, Seidlová V, **Berková H**, Hanzal V, Pikula J (2020). Trypanosomes in Eastern and Central European bats. *Acta veterinaria Brno*, **89**, 69-78.

Martínková N, **Baird SJE**, Káňa V, **Zima J** (2020). Bat population recoveries give insight into clustering strategies during hibernation. *Frontiers in Zoology*, **17**, 26.

Martínková N, Škrabánek P, Pikula J (2019). Modelling invasive pathogen load from non-destructive sampling data. *Journal of Theoretical Biology*, **464**, 98-103.

Němcová M, Pikula J, **Zukal J**, Seidlová V (2020). Diclofenac-induced cytotoxicity in cultured carp leukocytes. *Physiological Research*, **69**, S607-S618.

Piaček V, **Zukal J**, Seidlová V, Heger T, Němcová M, Přibyl M, Vitula F, Pikula J (2020). Fresh semen characteristics in captive accipitrid and falconid birds of prey. *Acta veterinaria Brno*, **89**, 291-300.

Pikula J, Heger T, Banďouchová H, Kováčová V, Němcová M, Papežíková I, Piaček V, Zajíčková R, **Zukal J** (2020). Phagocyte activity reflects mammalian homeo- and hetero-thermic physiological states. *BMC Veterinary Research*, **16**, 232.

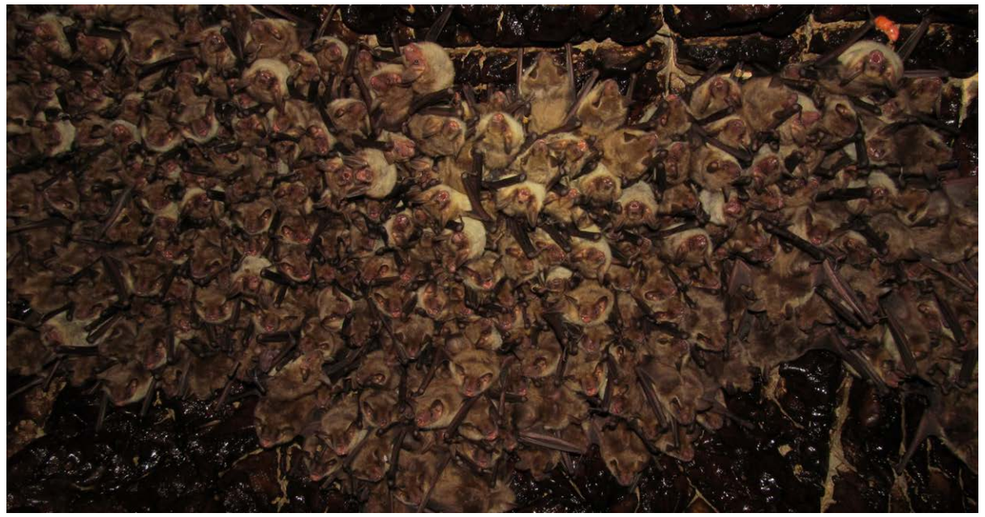
Ren P, Rajkumar SS, Zhang T, Sui H, Masters PS, **Martínková N**, Kubátová A, Pikula J, Chaturvedi S, Chaturvedi V (2020). A common partitivirus infection in United States and Czech Republic isolates of bat white-nose syndrome fungal pathogen Pseudogymnoascus destructans. *Scientific Reports*, **10**, 13893.

Seidlová V, **Zukal J**, Brichta J, Anisimov N, Apoznański G, Bandouchová H, Bartonička T, **Berková H**, Botvinkin AD, Heger T, Dundarova H, Kokurewicz T, Linhart P, Orlov OL, Piaček V, Presetnik P, Shumkina AP, Tiunov MP, Treml F, Pikula J (2020). Active surveillance for antibodies confirms circulation of lyssaviruses in Palearctic bats. *BMC Veterinary Research*, **16**, 482.

Veselská T, Homutová K, García Fraile P, Kubátová A, **Martínková N**, Pikula J, Kolařík M (2020). Comparative eco-physiology revealed extensive enzymatic curtailment, lipases production and strong conidial resilience of the bat pathogenic fungus. *Scientific Reports*, **10**, 16530.

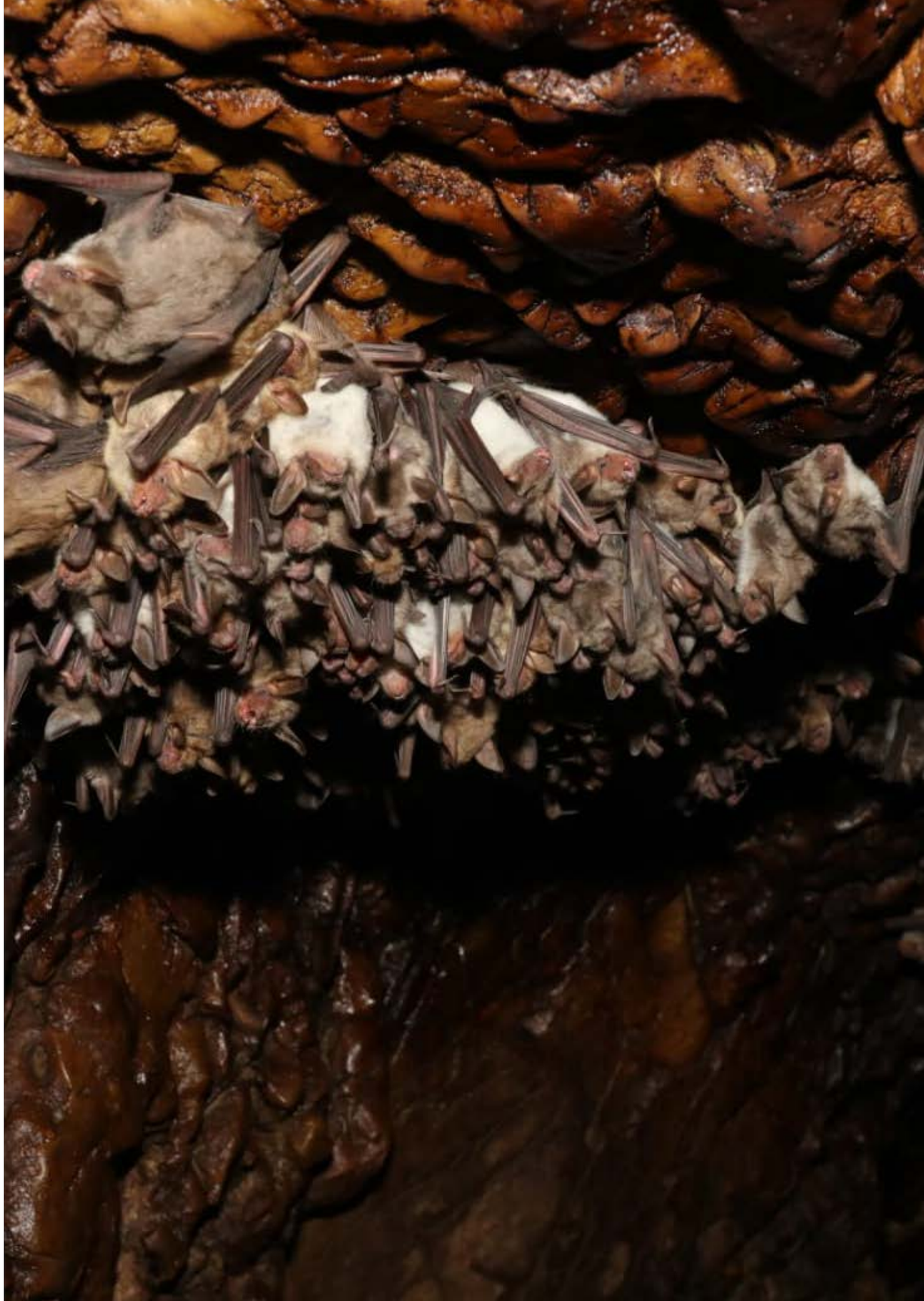
immune response and others reacting locally at the site of infection (Banďouchová et al. 2020, Veselská et al. 2020). The response of the immune system in heterotherms, such as bats, is also dependent on the individual's current physiological condition, which is likely to result in a low prevalence of microbial diseases in bat populations (Linhart et al. 2020, Seidlová et al. 2020).

While the causative agents persist permanently in bat populations, they quickly "jump" between individuals without causing death. The wide diversity of bat behavioural strategies and immune responses points to diverse evolutionary mechanisms that have evolved in response to similar environmental conditions and infections with the same pathogens.



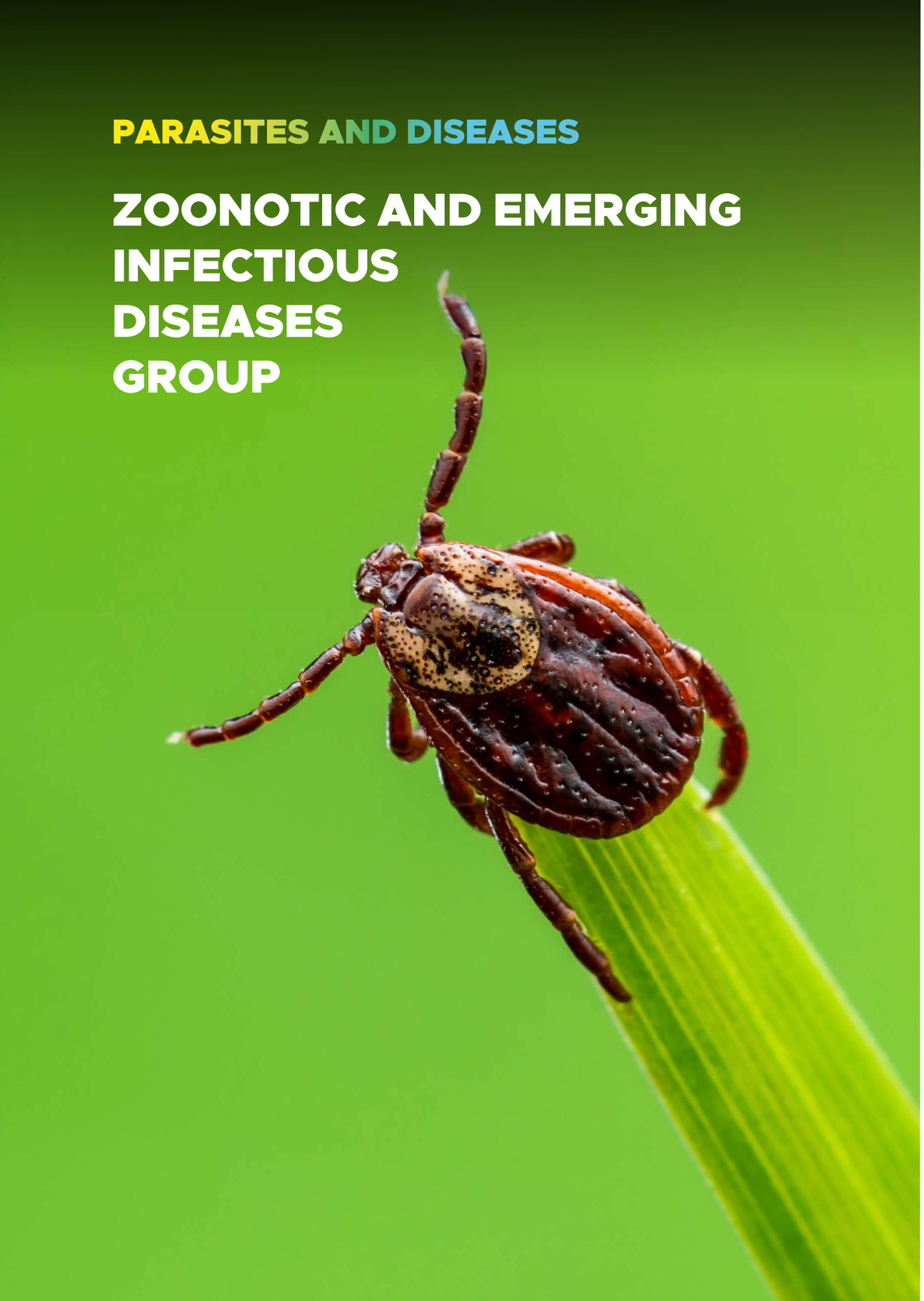
Bats roosting in the Peshchera letuchikh myshey (Chineta reserve, Altai Krai, Russia). This *Myotis blythii* maternity colony comprises approximately 1400 bats, including females and young-of-the-year. As shown, individual bats are tightly clustered during the nursery period, allowing for high contact intensity and quick spread of pathogens. | Photo by J. Zukal

Tissue sampling (biopsy) from the wing membrane of *Myotis myotis* targeted by ultraviolet transilluminators which visualize fluorescent WNS lesions on the wings of each bat. | Photo by J. Zukal



PARASITES AND DISEASES

ZOONOTIC AND EMERGING INFECTIOUS DISEASES GROUP



The exotic tick *Hyalomma rufipes*, a vector of Crimean-Congo haemorrhagic fever virus, found in the Czech Republic

Climate change has had an enormous impact on the spread of hematophagous arthropods (vectors of many vertebrate pathogens) into northern parts of Europe.

Hyalomma ticks are important vectors of several pathogenic agents, including Crimean-Congo haemorrhagic fever virus (CCHFV), Thogoto virus, Dhori virus, West Nile virus, Bhanja virus, Bahig virus and *Rickettsia aeschlimannii*. On October 24 2019, we found an adult *Hyalomma* tick affixed to the hind limb of a horse grazing at the "Nesyt" fishpond near Valtice in southern Moravia, Czech Republic.

The horse was born in the Czech-Moravian Highlands and had not left the Republic, or at least not over the previous five years. The animal was regularly put out to pasture throughout the season and tended to move around the area between the towns of Valtice and Mikulov, very close to the Czech-Austrian border. The most probable mechanism explaining how "our" tick appeared in the Czech Republic is through transport as a larva or nymph on a migrating bird, later moulting into an adult in south Moravia.

While our finding of one adult *Hyalomma rufipes* on a host does not mean that this tick species has become established in the Czech Republic, the fact that *H. rufipes* is an efficient vector of CCHF or pathogenic *R. aeschlimannii*, makes increased vigilance for *Hyalomma* ticks and surveillance for exotic pathogenic agents in central and northern Europe highly recommendable.

Male of *Hyalomma rufipes* collected at the Sedlec site. | Photo by J. Vojtíšek

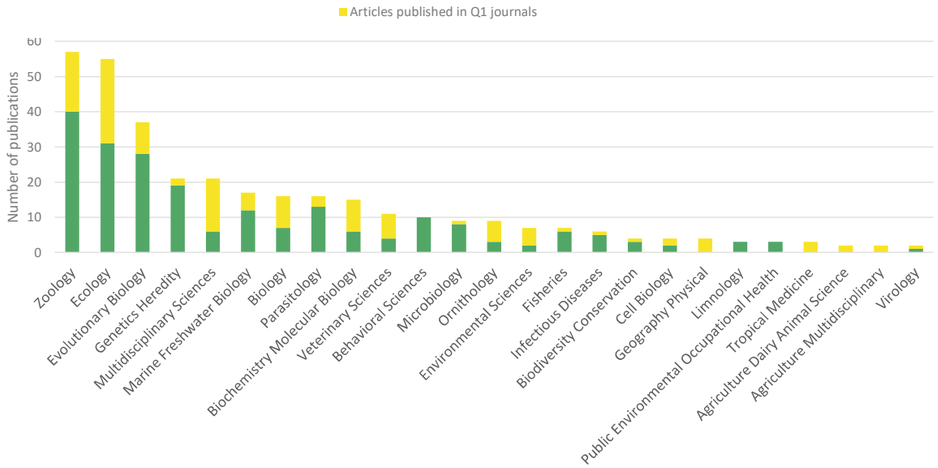
The landscape at the Sedlec study site. | Photo by I. Rudolf

Hubálek Z, Sedláček P, Estrada-Peña A, **Vojtíšek J**, **Rudolf I** (2020). First record of *Hyalomma rufipes* in the Czech Republic, with a review of relevant cases in other parts of Europe. *Ticks and Tick-borne Diseases*, **11**, 101421.

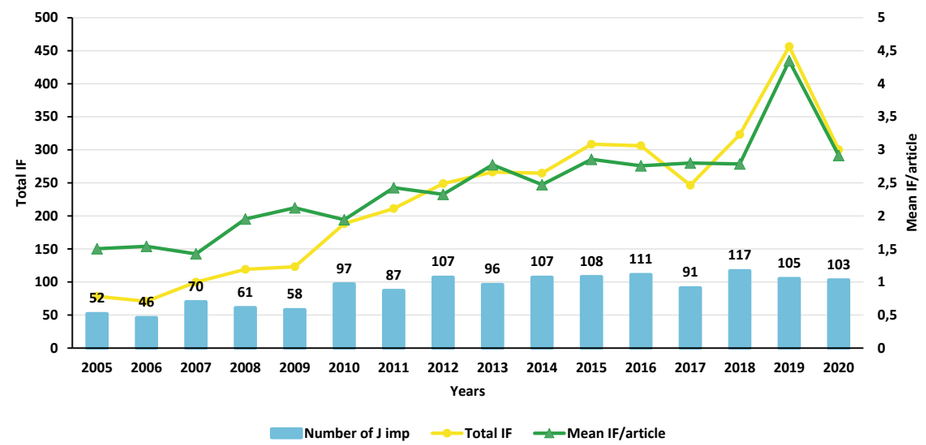
SCIENTIFIC RESULTS

Summary of publication output

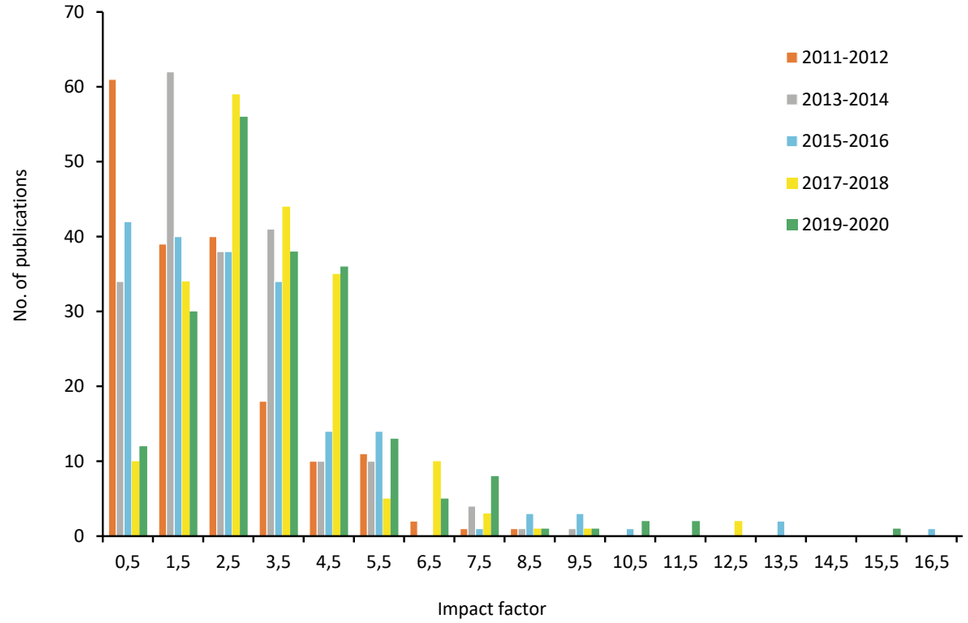
Researchers at the IVB produced 208 scientific articles in SCI (Science Citation Index) journals over 2019-2020. The publication profile and main scientometric criteria are shown below.



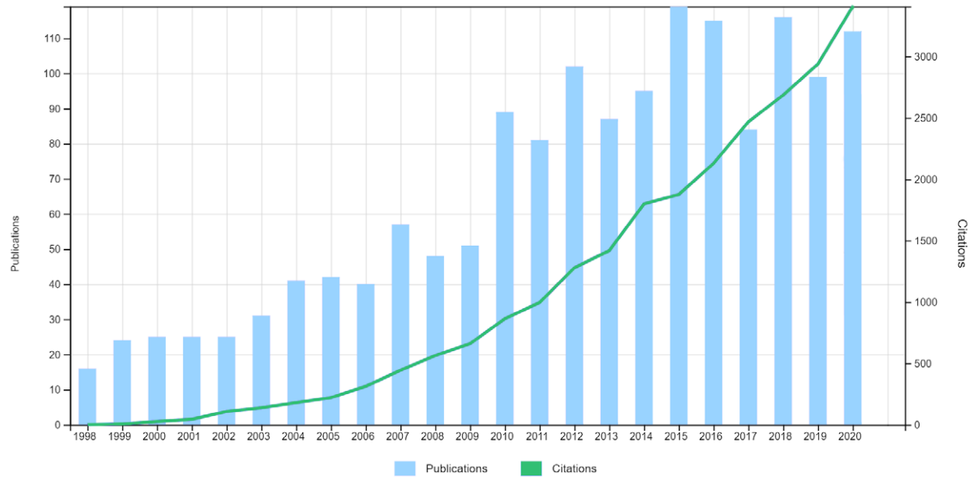
Distribution of papers categorized according to the Web of Science database over 2019-2020



The impact factor (IF) values of journals published over the last two years confirm the increasingly high quality of IVB publications



The distribution of scientific articles in SCI (Science Citation Index) journals factors once again shifted toward higher values over 2019-2020



Citations of IVB papers over the last two years confirm the increasing trend seen in previous years (note that the Institute of Vertebrate Biology was founded in 1998), graph adopted from Web of Science database

Geographic distribution of the most important international cooperation activities

NORTH AMERICA

- Centre for Disease Control and Prevention (CDC), Fort Collins, Colorado, USA
- Colorado University Denver, Colorado, USA
- Cornell University, Ithaca, USA
- Denver University, Colorado, USA
- Field Museum of Natural History, Chicago, USA
- Minnesota University, USA
- Northern Arizona University, USA
- Portland State University, Oregon, USA
- Texas A&M University, College Station, Texas, USA
- University of Colorado, Boulder (u Denveru), USA
- University of Colorado, Denver, USA
- University of Connecticut, Storrs, Connecticut, USA
- Université de Sherbrooke, Sherbrooke, Canada
- United States Department of Agriculture Forest Service, Columbia, Missouri, USA
- U.S. Fish and Wildlife Service, La Crosse Fish Health Center-Midwest Fisheries Center, Onalaska, Wisconsin, USA
- U.S. Geological Survey, Fort Collins Science Center, Colorado, USA

SOUTH AMERICA

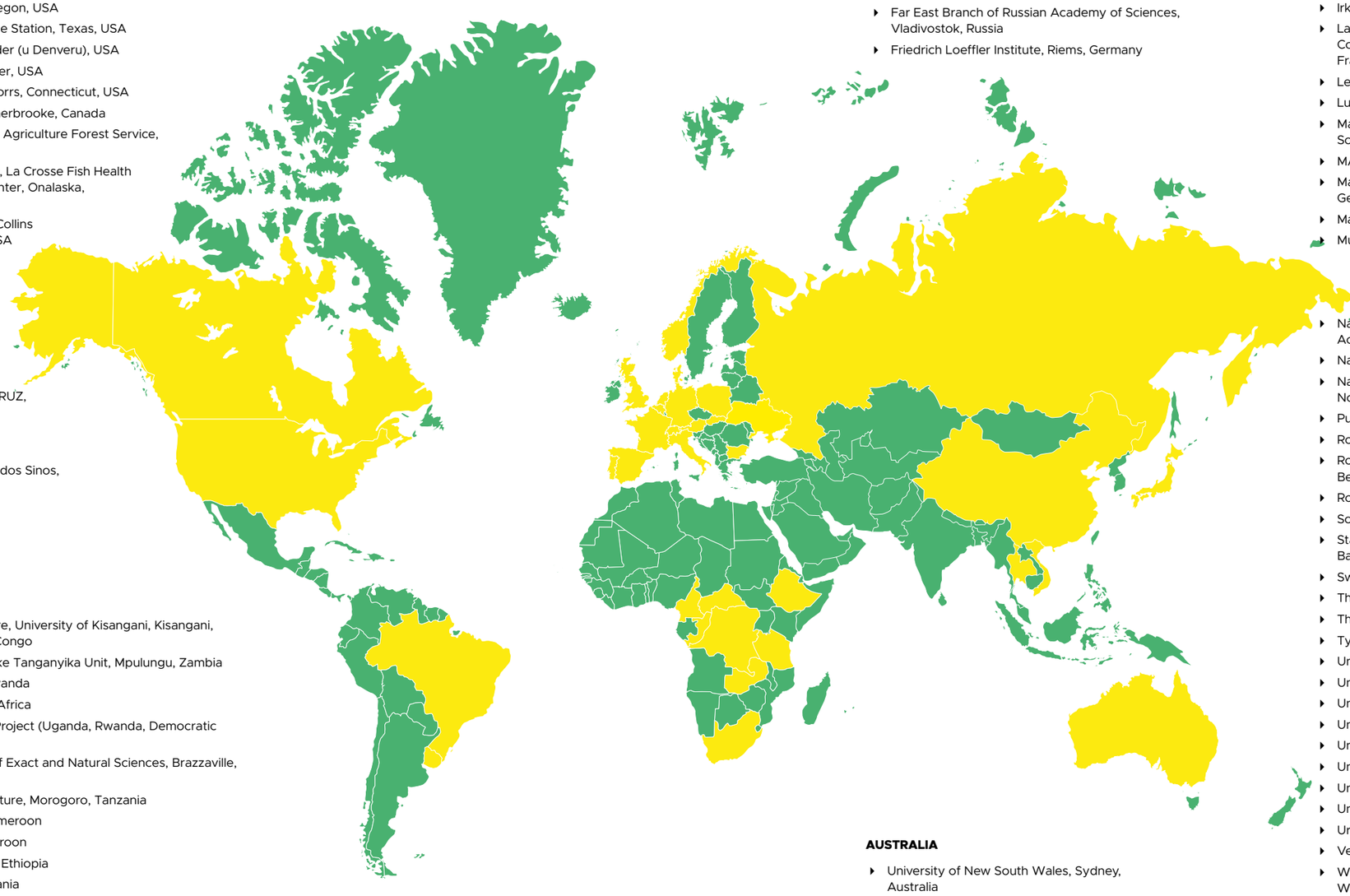
- Instituto Oswaldo Cruz, FIOCRUZ, Rio de Janeiro, Brazil
- Universidad de la República, Montevideo, Uruguay
- Universidade do Vale do Rio dos Sinos, Sao Leopoldo, Brazil

AFRICA

- Biodiversity Monitoring Centre, University of Kisangani, Kisangani, Democratic Republic of the Congo
- Department of Fisheries – lake Tanganyika Unit, Mpulungu, Zambia
- Dian Fossey Gorilla Fund, Rwanda
- Kruger National Park, South Africa
- Mountain Gorilla Veterinary Project (Uganda, Rwanda, Democratic Republic of Congo)
- National Research Institute of Exact and Natural Sciences, Brazzaville, Republic of the Congo
- Sokoine University of Agriculture, Morogoro, Tanzania
- University of Buea, Buea, Cameroon
- University of Dschang, Cameroon
- University of Mekelle, Tigray, Ethiopia
- Ugalla Primate Project, Tanzania
- World Wildlife Fund Central African Republic

ASIA

- Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, China
- Institute of Ecology and Biological Resources (IEBR), Vietnamese, Academy of Science and Technology, Hanoi, Vietnam
- Oita University, Dannoharu Oita-shi, Japan
- Primate Research Institute, Kyoto University, Japan
- Udonthani Rajabhat University, Mueang Udon Thani District, Udon Thani, Thailand



EUROPE

- Aarhus University, Aarhus, Denmark
- Administration of the Lazovsky State Reserve and National Park Zov Tigra, Russia
- Aix Marseille University, Marseille, Francie
- A. N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, Moscow, Russia
- Biomedical Research Centre, SAV, Bratislava, Slovakia
- Biological Station Lake Neusiedl, Austria
- Centre de Biologie pour la Gestion des Populations, Montferrier sur Lez cedex, France
- CIBIO-InBIO, Research Centre in Biodiversity and Genetic Resources, Portugal
- Conservation Genetics Group, Senckenberg Research Institute and Natural History Museum Frankfurt, Gelnhausen, Germany
- Far East Branch of Russian Academy of Sciences, Vladivostok, Russia
- Friedrich Loeffler Institute, Riems, Germany
- German Primate Center, Leibniz Institute for Primate Research, Germany
- INRAE, UR EABX, Centre Nouvelle-Aquitaine, Cestas Cedex, France
- Institut de Radioprotection et de Surete Nucleaire, Cadarache, France
- Institute of Biodiversity and Ecosystem Research, BAS, Sofia, Bulgaria
- Institute of Biology, Karlsruhe University of Education, Karlsruhe, Germany
- Institute of Hydrobiology, NAS of Ukraine, Kyiv, Ukraine
- Institute of Marine Biology, NAS of Ukraine, Odessa, Ukraine
- Institute of Parasitology, Slovak Academy of Sciences, Slovakia
- Irkutsk State Medical University, Irkutsk, Russia
- Laboratoire Interdisciplinaire des Environnements Continentaux, CNRS – Université de Lorraine, Metz, France
- Leiden University, Leiden, Netherlands
- Lund University, Lund, Sweden
- Mammal Research Institute, Polish Academy of Sciences, Białowieża, Poland
- MARE, Universidade de Lisboa, Lisboa, Portugal
- Max Planck Institute for Biology of Ageing, Cologne, Germany
- Max Planck Institute for Ornithology, Seewiesen, Germany
- Muséum National d´Histoire Naturelle, Paris, France
- National Museum of Natural History at the Bulgarian Academy of Sciences, Sofia, Bulgaria
- National Zoological Garten Bojnice, Bojnice, Slovakia
- Natural History Museum, University of Oslo, Oslo, Norway
- Public Health England, Porton Down, England
- Robert Koch Institute, Berlin, Germany
- Royal Belgian Institute for Natural Sciences, Brussels, Belgium
- Royal Zoological Society of Antwerp, Belgium
- Scuola Normale Superiore, Pisa, Italy
- State Nature Conservancy of the Slovak Republic, Banská Bystrica, Slovakia
- Swiss Ornithological Institute, Sempach, Switzerland
- The Humboldt-Universität zu Berlin, Berlin, Germany
- The University of Sheffield, UK
- Tyumen State University, Russia
- University of Edinburgh, Edinburgh, Scotland
- University of Graz, Graz, Austria
- University of Groningen Netherlands
- University of Lodz, Lodz, Poland
- University of St Andrews, UK, Scotland
- Université Montpellier, France
- University of Antwerp, Antwerp, Belgium
- University of Barcelona, Barcelona, Spain
- Ural State Medical University, Yekaterinburg, Russia
- Veterinary University Vienna, Austria
- Wrocław University of Environmental and Life Sciences, Wrocław, Poland
- Zurich University, Zurich, Switzerland

AUSTRALIA

- University of New South Wales, Sydney, Australia
- University of Sydney, Sydney, Australia

APPLICATION AND COMMERCIALISATION OF RESEARCH OUTPUTS

The transfer of knowledge and implementation of technology into practice is considered an important activity complementing the main mission of the Institute of Vertebrate Biology. Between 2010 and 2020, the Institute's intellectual property database increased with 36 applied results, consisting of two patents (national and European), seven utility models, 13 methodologies, four verified technologies, two prototypes, six functional samples, one software and one trademark. One project in particular, undertaken between 2016 and 2019 to support the "Commercialisation of results of zoological research - applications for nature conservation practice" proof-of-concept and financed under the GAMA TACR (Technology Agency of the Czech Republic) program, contributed heavily to the substantial increase in applied results, providing 29 of the 36 applications. As part of the commercialisation the Institute's research and development results between 2019 and 2020, contracts were completed between Czech and foreign partners to the value of approximately CZK 9.2 million.

Trademark of S7iFish software

These collaborations were carried out primarily in the form of sales of licenses, contract research, expert services and custom research.

Between 2019 and 2020, the institute developed a new software package called S7iFish (based on the European patent), a web application for mapping fish diversity in nature and aquaculture based on genetic markers that help identify particular species. Four genetic kits have been developed specifically for fish breeding and conservation management, i.e. STR Multiplex ASPident11, STR Multiplex ASPident 12, STR Multiplex TRUTident9 and STR Multiplex OMident12.

The Institute cooperated with a wide range of institutions, universities, scientific centres, angling unions and fish farming concerns. These included the University of South Bohemia in České Budějovice, the Nature Conservation Agency of the Czech Republic (NCA CR), Czech Academy of Sciences' Biology Centre, the Czech Anglers Union, the University of Ostrava, the Czech Bat Conservation Society (ČESON), the European Centre for Disease Prevention and Control, the European Mammal Foundation, the Czech Ministry of the Environment, various River Basin Water Authorities (e.g. Elbe, Oder, Morava), the Krkonoše Mountains National Park (KRNAP), Šumava National Park, AQ-Service s.r.o., Wild Park n.o., ZOO parks and many others.

The MultiplexOMident12 kit for genetic analysis fish. | Photo by J. Mendel

Rainbow trout *Oncorhynchus mykiss.* | Photo by P. Jurajda

OTHER ACTIVITIES

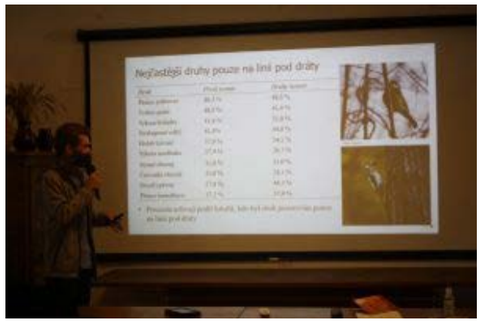
POPULARISATION ACTIVITIES

Popularisation of science and research is an important part of the IVBs activities. In 2019, we organised many seminars, workshops, field excursions and other activities for the public. Unfortunately, however, 2020 was marked by the COVID-19 outbreak, which significantly affected the frequency of popularisation activities.

Activities for schools and university students

Our researchers take pride in mentoring high school students who can participate in different research tasks as part of the Czech Academy of Science's Open Science program or Secondary School Professional Activity (SSPA) course.

Organised by the Czech Ornithological Society, the 2nd Students Ornithological Conference, which took place in Prague last September, was focused on primary and secondary school students. The conference was attended by Martin Greško (mentor Michal Šulc, IVB) and Jakub Hrouda (mentor Vojtěch Brlík, IVB). Martin Greško's lecture was entitled "Variability in the appearance of cuckoo eggs during the nesting season and its effect on mimicry", while Jakub Hrouda presented the results of his SSPA concerning the importance of disturbed environments under high voltage pylons for local species diversity and bird abundance. The work of Jakub Hrouda took second place in the national round of the SSPA and 1st place at the Student Ornithological Conference, where both the idea and its elaboration attracted attention.



PhD students from the IVB present their most interesting results to the wider public at the 2019 and 2020 Science Exposition in Prague, EXPO Letňany. | Photo from IVB archive

Jakub Hrouda's lecture, which won 1st prize at the conference, attracted attention for its concept and thorough elaboration. | Photo from IVB archive

Martin Greško gave a very interesting lecture on variability in cuckoo eggs. | Photo from IVB archive

The IVB also organises many educational activities, including the ornithology course for University students, which took place in April 2019 at the Mohelno field station, led by Vojtěch Brlík and Kryštof Horák. This course aims to introduce students to all aspects of ornithological practice, such as how to catch and ring birds, how to observe them and how to recognise different birds by their calls.

School excursions are organized mostly at the research facility in Studenec, where students can enjoy the beautiful highland countryside with its many ponds. | Photos from IVB archive

Excursions are always tailored to each group (educational level, numbers attending and time spent at the research facility) and may include a visit to see the newt, mouse and bird breeding facilities or a tour round the laboratories. It is possible to adapt excursions to the needs of the youngest visitors or provide a professional lecture for university students. We also visit schools, where we may present educational programs geared toward evolution and adaptation, or provide talks on the latest results from our research.

Numerous popularization activities are organized in the Studenec research facility. | Photos from IVB archive

ACTIVITIES FOR THE PUBLIC

The IVB also organises many activities for the general public, including excursions all of our facilities during Science and technology Week (Open Days), the Science Fair in Prague (organised in 2019 but cancelled in 2020), popularisation lectures and ornithological excursions. We also help organise the regular International bat nights in the Moravian Karst and at Brno Zoo.

Jan Zukal showing a bat to members of the public at a science popularisation day in Třebíč, 2019. | Photo from IVB archive

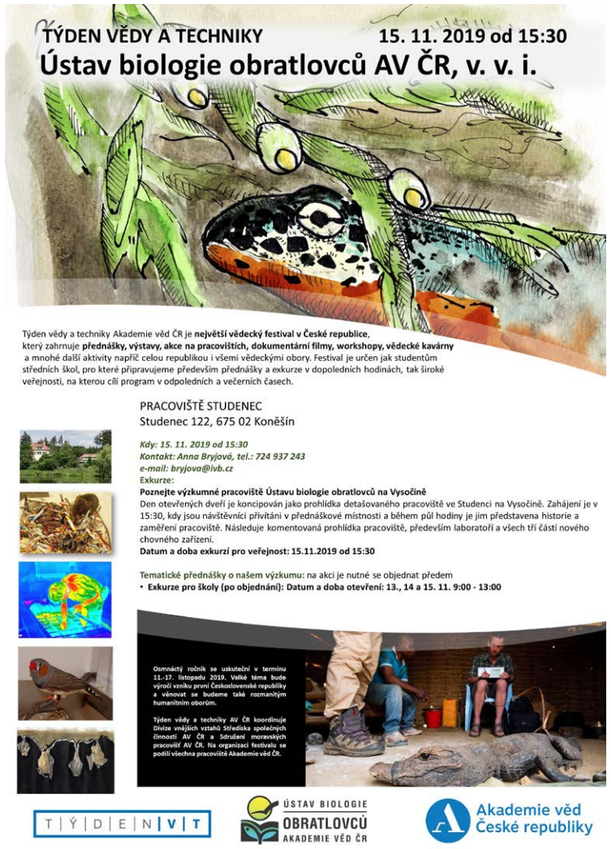
Science Fair 2019

Organised annually by the Czech Academy of Sciences, the Science Fair is the largest popular science event in the Czech Republic. The fair presents science in all its forms and allows visitors to experience the world of natural, technical and social sciences by presenting at one site the most interesting findings that Czech science has to offer. In June 2019, the fifth Science Fair once again took place in the modern exhibition halls of the PVA EXPO complex in Prague. Over 100 exhibitions from the Czech Academy of Sciences, universities, scientific institutions and innovative companies, as well as other external exhibitors, provided new insights to scientific enthusiasts. The IVB presented results of its research into brood parasitism in avian and fish study systems and the thermal ecology of newts.

PhD students from the IVB present their most interesting results to the public at the 2019 EXPO Letňany Science Fair in Prague. | Photos from IVB archive

Open Door days

Over the course of the Czech Republic's 'Science and technology Week', the Czech Academy of Sciences opens its doors to the public in a series of open house events. All IVB research facilities participated in the event and welcomed a wide selection of the public through their doors. Visitors gained insights into the research taking place at the various facilities and were able to observe the normal functioning of the laboratories and breeding facilities.



The Studenec Research facility welcomed students from a number of schools during the Science and Technology Week. | Photos by A. Bryjová

STRATEGY AV21

The Czech Academy of Sciences
Strategy AV21
Top research in the public interest

ROZE

The IVB is an active institute within Strategy AV21, the new research strategy of the Czech Academy of Sciences aimed at increasing direct contact and collaboration between the Academy and the wider application sector. As part of these efforts, a number of activities took place over 2019–2020 under the 'Diversity of Life and Health of Ecosystems Research Programme (ROZE)'. In addition to supporting the founding of the National Animal Genetic Bank and the experimental breeding facility (see below), Strategy AV21 enabled the IVB to organise a range of field excursions and seminars for the general public and for primary and secondary school and university students on 'climate change and its effects on biodiversity' under the project 'Continuous Education and Popularisation of Scientific Research'.

In 2019, the IVB organised a number of public and school events aimed at both promoting the output of the institute and, at the same time, passing on the latest scientific information on current topics. Some of these activities were organised in cooperation with other bodies, such as a public seminar on the bark beetle calamity in the Třebíč region, organised together with the Pozďatín Agricultural School. This particular event was attended by politicians, experts from the Czech Forestry Authority and the non-profit conservation organisation "Hnutí DUHA". In addition to preparing lectures, seminars and workshops, a number of 'comics' were prepared in cooperation with the Czech ornithology organisation, Mendel University and the University of Agriculture in Prague, including a poster on the diversity of the agricultural landscape and its implications for biodiversity. These comics were also presented at later events, including the 2019 Science Fair in Prague.

In 2020, ROZE was included into a new programme named 'Rescue and Restoration of the Landscape', the aim of which is to identify possible future threats to the functioning of our landscape that could result in a deterioration in the quality of ecosystem services provided. As part of this programme, the academy is addressing the development of sustainable ways of using the landscape and the development of methods for restoration of damaged landscapes. The IVB itself is undertaking two projects under this new programme: 'the Biodiversity of Cultural Landscapes', led by Martin Šálek and Alena Fornůsková, and 'Saving Genetic Diversity *ex situ*', led by Barbora Rolečková (for more information on the latter project, see below).

Martin Šálek (on the left) cooperates with small-scale farmers on improving the cultural landscape. | Photo by M. Šálek

The little owl (*Athene noctua*) is a flagship species for healthy cultural landscapes. | Photo by M. Šálek

NATIONAL ANIMAL GENETIC BANK OF THE CZECH REPUBLIC

Biological collections of the IVB

National Animal Genetic Bank • CZ

Since the foundation of the institute in the 1950s, considerable attention has been paid to establishing its biological collections. In the past, institutional researchers undertook numerous field expeditions abroad (mainly eastwards during the communist era), in which valuable material was collected and subsequently used for the preparation of stuffed specimens, skulls and skeletons.

From a geographical perspective, much of the IVB collection of vertebrate voucher specimens comes from the Czech Republic and Slovakia (former Czechoslovakia); however, there are also numerous examples of mammals from the Balkans, Russia, Egypt, Afghanistan, Senegal and many other European and non-European countries. Over the years, this classic collection has been continuously supplemented, though less intensely since 2000. Of the most recently collected material, a collection of small African rodent skulls collected between 2010 and 2020 is the most numerous. By 2020, the collection consisted more than 44 000 specimens, including the type individuals of the Tatra pine vole (*Microtus tatricus* Kratochvíl, 1952) and Tatra marmot (*Marmota marmota latirostris* Kratochvíl, 1961). The vertebrate specimen data available at the IVB is presently in the process of being digitised and will be fully published in the near future; however, it is possible to visit the collection and material is available from the curator on request.

Tissue samples were were collected in the field for future genetic analysis by Prof. Jan Zima in the early 1990s, with others increasingly following this trend as the use of genetic analysis on wild species has increased dramatically in line with technological developments. In 2015, the IVB established its own genetic bank (**IVB Genetic Bank**), as well as a network of zoological genetic repositories across the Republic known as the **National Animal Genetic Bank** (NAGB).

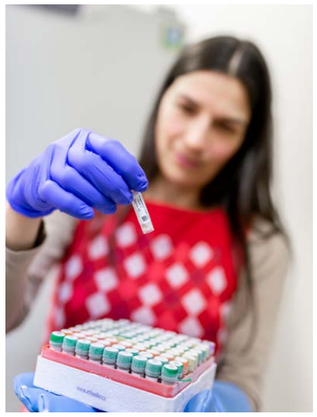
The NAGB presently has six full members, two of which publish genetic sample data on online data portals, while other sister organisations (e.g. natural history museums and animal rescue stations) provide genetic samples. The main aim of the NAGB is to eventually obtain samples of all vertebrate taxa present in the Czech Republic, thereby allowing researchers to monitor changes in the genetic diversity of species and populations over time, but also to make freely available those samples already in its collections (e.g. those from completed scientific projects) for further research.

With around 10 000 samples already published, the NAGB has started to become more widely-used by Czech researchers and zoologists, and samples are increasingly being used by researchers around the world. Recently, the bank's samples have been used in studies of climate change impacts on intraspecific genetic diversity of the chamois (genus *Rupicapra*), a mountain specialist (University of Savoie Mont Blanc, France), the evolutionary history of common and Iberian moles (genus *Talpa*) in Europe (National Museum of Natural History in Paris, France) and a study of IVB Fish Ecology Research Group assessing freshwater fish communities based on the analysis of environmental DNA found in water samples.

In addition to providing access to its existing genetic samples, the NAGB is continuously updating its collection with new samples, not just from the Czech Republic but from all over the world. At present, most of the published samples comprise small terrestrial mammals from East Africa and includes almost all Central European fish species, though there are also numerous examples of other vertebrate species from Central Europe, the Balkans, the Middle East and Russia. However, from a taxonomic point of view, reptiles and amphibians are presently under-represented in the bank and new samples are eagerly sought.

The NAGB encourages those organisations that already manage their own collections of wild animal genetic samples to become members and join the NAGB network, which will allow them to present their sample data on public databases, thereby increasing the overall number of genetic samples available to researchers worldwide, and to benefit from the combined application of financial, technical and legislative solutions related to biobanking.

NAGB samples can be searched using the public NAGB database (http://data.ngbz.cz/search/index) or that of the Global Genome Biodiversity Network (http://www.ggbn.org/ggbn_portal/search/index).



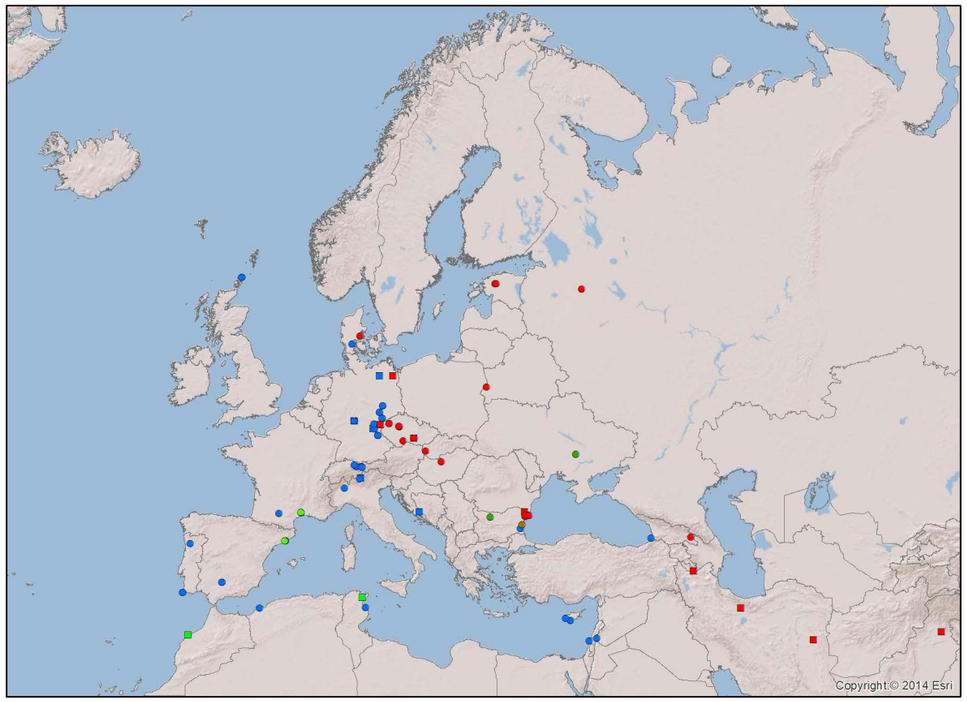
A typical genetic sample stored in the IVB Genetic Bank deep freezer (-80 °C) comprises a small piece of animal tissue stored in a glass tube with pure ethanol and labelled with basic information on the species and origin of the sample. | Photos from IVB archive

BREEDING FACILITIES

Mouse breeding facility

The IVB's mouse breeding facility at the Studenec external research facility houses the largest collection of wild derived strains (WDS) in the world. This unique collection was created by combining the large collection of strains developed at the IVB since 2008 by the team of Jaroslav Piálek with the WDS collection held since 1976 by Francois Bonhomme in France. Currently, there are more than 70 strains derived from the wild house mouse (*Mus musculus*), along with strains derived from the Mediterranean mouse (*Mus spretus*) and Macedonian mouse (*Mus macedonicus*).

The breeding facility specialises in experimental research and presently focuses on the study of speciation, particularly as regards hybrid zones between mouse subspecies. All mice strains are available to the wider scientific community and interested parties should contact Jaroslav Piálek at jpialek@ivb.cz. More information on the Mouse breeding facility can be found at https://housemice.cz/en



The mouse breeding facility houses almost four thousand mice. | Photo from IVB archive

Jarosav Piálek showing Eva Zažímalová, President of the Czech Academy of Sciences, around the mouse breeding facility. | Photo from IVB archive

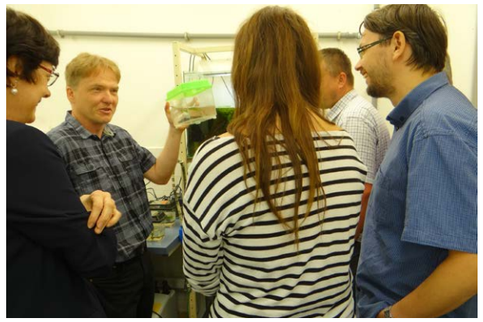
The mouse breeding facility in Studenec was fully reconstructed in 2017. | Photo from IVB archive

The mouse breeding facility is often used for popularisation events and for tours during the Science and Technology week. | Photo from IVB archive

Newt breeding facility

The newt breeding facility, led by Lumír Gvoždík, is used for experimental research, with a focus on behavioural and ecophysiological research of caudate amphibians. The results of thermal ecology research will make it possible to better predict the impact of intensive human-induced changes on individual ecosystems. Further, a greater understanding of vertebrate temperature-physiological dependence will improve our chances of reversing the present risks of global climate change.

A larval alpine newt (*Ichthyosaura alpestris*). | Photo by L. Gvoždík



The newt breeding facility in Studenec. | Photos from IVB archive

Bird breeding facility

The bird breeding facility, led by Tomáš Albrecht, specialises in experimental research, with a particular focus on sexual selection and the study of life strategies (e.g. evolution of aging). The study of reproductive mechanisms and mating systems in particular may help explain the emergence of infertility and help find ways to avoid it.

Bird breeding facility, Tomáš Albrecht (on the left) presenting his research activities to the president of Czech Acadamy of Sciences Eva Zažímalová (in the middle). | Photo from IVB archive

Fish breeding facility

The Brno fish breeding facility, led by Martin Reichard, was upgraded and re-accredited in 2018. It currently consists of seven indoor rooms with aquaria, 100 outdoor tanks and a large pond for underwater behavioural observations. The facility has proved indispensable for several ongoing projects on various aspects of fish behaviour, evolution and ecology.

The major fish groups housed at the facility include several species of bitterling fishes (*Rhodeus* spp.), African and Neotropical annual killifishes and the Tanganyikan cuckoo catfish (*Synodontis multipunctatus*) and its cichlid host. | Photos from IVB archive

CONSERVATION PROJECTS

Project ATHENE – The Little Owl in Danger and a New Rescue Program

The little owl is a predator inhabiting a range of open and semi-open habitats, though in Western and Central Europe it is mainly associated with human-modified agricultural landscapes. | Photo from Wikimedia commons

While a report on project Athene was presented in the previous IVB Biennial report (2017-2018), we would like to present an update for this biennial report as its activities have now led to the inauguration of a rescue program for the critically endangered little owl (*Athene noctua*).

The main aim of the ATHENE project is to protect the remaining Czech populations of the little owl (*Athene noctua*) and support it's spread through monitoring, research and conservation measures. The ATHENE project, which is based on a cooperative partnership between the Dresden Environmental Centre, the Czech Society for Ornithology, the Museum of the City of Ústí nad Labem and the IVB, forms part of the 2014-2020 Czech Republic-Free State of Saxony cross-border cooperation program. The project is supported by the European Union under the European Regional Development Fund.

The little owl was once our most common owl, with a population size of in the tens of thousands. Today, however, the little owl is one of our most endangered species, the Czech breeding population having declined by around 87–94 % over the last 20 years.

According to Martin Šálek of the IVB, co-author of the little owl rescue program, which was approved by the Czech Ministry of environment in August 2020, its numbers are now estimated at just 100–130 pairs. The main aims of the rescue program are to ensure that farmland within the territories of little owls provides a sufficient food supply throughout the year; to make safe dangerous sites in human settlements where small owls nest (e.g. little owls often drown in uncovered barrels); and to reconnect existing mosaic-like populations by providing nesting sites or by releasing captive owls into suitably prepared habitats. The ultimate goal is to increase the number of owls in the Czech Republic to at least 1000 pairs.

The preparation and coordination of the rescue program is being implemented by the Nature and Landscape Protection Agency of the Czech Republic, in cooperation with other professional institutions and entities. The Czech Ornithological Society, the IVB and the NGO TYTO z.s. have all played a significant role in the preparation of the Little Owl Rescue Program.

We are looking for a cat, a wildcat!

The secret life of wildcats

The wildcat is one of the rarest and least known species of Czech fauna. In the 17th century, it was found throughout Bohemia and Moravia; however, since then, human persecution and deforestation saw its numbers gradually decrease, until it was declared locally extinct in 1952. In 2011, camera traps in the Šumava National park provided the first evidence for its re-occurrence in the Czech Republic, with further records following in subsequent years along the Czech-Slovak border (see Dula et al. (2019) for a review of these records).

According to Martin Duľa, author of the study and one of the coordinators of wildcat monitoring for Friends of the Earth, long-term camera-trapping of large carnivores along the edge of the Western Carpathians has also provided valuable information regarding the occurrence of wildcats in the Javorníky and Bílé Karpaty Mts. in Slovakia. In 2019, for example, we recorded a dominant female with three cubs on the Slovak side of the Javorníky Mts., close to the Czech border.

Dispersing individuals from these areas can play an important role in the recolonisation of suitable habitats in the Czech Republic. We found further evidence of such dispersion movements in adjacent mountain ranges, such as the Vsetínské Beskydy and Hostýnské vrchy Mts.

Hybridisation with the domestic cat

Alongside poaching and the loss of suitable habitat, one of the main threats to wildcats is hybridisation with domestic cats. According to the IVBs Jarmila Krojerová, the coordinator of the project, use of morphometric skull measurements and discrimination based on coat pattern (i.e. number and position of stripes on the body, sides and tail) have proved problematic, especially in the case of hybrid individuals, and while non-invasive genetic monitoring has been successfully used to identify hybrid individuals elsewhere, it has not yet been applied in the Czech Republic or Slovakia. Studies across Europe that have studied the crossbreeding rate with domestic cats differ significantly in their results. In Hungary and Scotland, for example, wildcat populations have been significantly affected by hybridisation, while in Germany only 3.5% of wildcats in the wild have been identified as hybrids.

As yet, it is not known whether crossbreeding is a problem for the West-Carpathian wildcat population or not. To address this, we will use carcasses, museum samples and, especially, non-invasive hair samples, obtained with the help of hair traps in the field, to assess the degree of hybridisation in this region. At the same time, genetic analysis will be used to identify individuals, determine genetic variability within the population and assess the degree of inbreeding, which will be important for future species protection efforts.

The project is financially supported under the European Union's Interreg program V-A SK-CZ 2014-2020.

The European wildcat (*Felis silvestris*) is a small wildcat species native to continental Europe, Scotland, Turkey and the Caucasus. Its fur is brownish to grey with stripes on the forehead and on the sides and has a bushy tail with a black tip. | Photo by J. Červený

Use of non-invasive genetic sampling and the genotyping of samples using sets of microsatellite markers will be essential for studying such an elusive species. | Photo by M. Pravdová

A wildcat rubbing itself on a hair trap in the Strážovské vrchy Mts. | Photo from Bojnice National Zoo camera trap

Reference:
Duľa M., Váňa M., Dekař P., Bojda M., Kutal M. 2019. Recentní záznamy kočky divoké (*Felis silvestris*) na česko-slovenském pomezí. *Acta Carpathica Occidentalis* 10: 86–90.

MEETINGS ORGANISED BY THE INSTITUTE

“Zoological Days” Conference 2019 (Brno) and 2020 (Olomouc)

The annual national zoological congress of the Czech Zoological Society, better known as the “Zoological Days” conference, was first held in Brno in 1969. Ever since, it has been a popular meeting place for Czech and Slovak zoologists. Since 2008, the conference has been held in Brno in odd years and in another Czech university town in even years. In both 2019 and 2020, the IVB was the main organiser of the Zoological days conference.

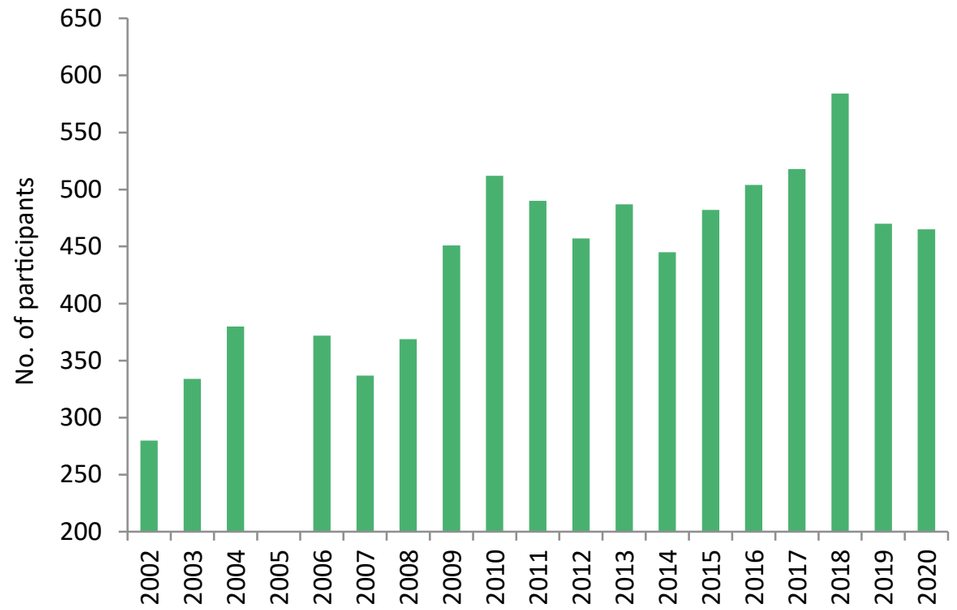
In 2019 (7 - 8.2.2019), the conference was organised in Brno in collaboration with the Department of Botany and Zoology of Masaryk University’s Faculty of Science. The conference took place at Masaryk University’s Faculty of Economics and Administration, which is an ideal site, being situated just next to the IVB headquarters, providing a fine location for such a large and important conference. The conference hosted 480 zoologists, who presented 128 lectures over 21 lecture sessions and presented 131 posters. The conference started on Wednesday with a plenary lecture by Martin Reichard (IVB) on short-lived fish.

In 2020 (6 – 7.2.2020), the conference was organised in partnership with the Department of Ecology and the Environment of the Faculty of Science, Palacký University Olomouc. The program opened on Wednesday with a plenary lecture given by Vladimír Remeš from Palacký University Olomouc on the topic "Macroevolution of bird behaviour and colouring on a global scale.“ A total of 465 participants attended 130 lectures in 21 parallel lecture sessions and presented 133 posters.

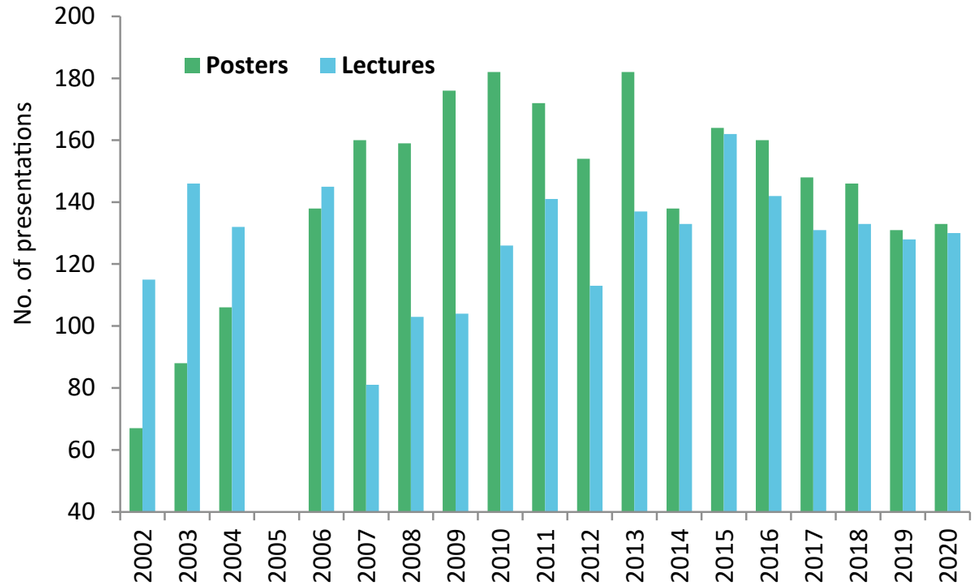
On this occasion, in addition to the traditional prizes awarded for the best student lectures and posters, a new award was given to commemorate the recent passing of Prof. Jan Zima of the IVB. The first “Jan Zima Prize for significant contributions to the biological research of vertebrates”, awarded to researchers in the “junior researcher” category, was presented to Zuzana Musilová of Charles University for her contribution to the field of fish evolution. At the same time, the “Jiří Gaisler Award for significant contributions to the biological research of vertebrates ” in "senior researcher“ category, the award went to Radim Šumbera of the University of South Bohemia in České Budějovice, for his long-term contributions regarding the life of underground mammals.

For more information, please see **http://zoo.ivb.cz/**.

"Zoological Days" conference is the biggest zoological conference organized in the Czech republic. | Photos from Zoological days archive



The number of participants registering for the "Zoological days" conference reached a plateau of 450-500 individuals in 2009 (no conference was organised in 2005).



The "Zoological days" conference offers a unique opportunity to see hundreds of presentations covering all areas of zoological research currently undertaken in the Czech Republic and Slovakia over two days.

The 13th African Small Mammal Symposium

The African Small Mammal Symposium (ASMS) takes place every four years and has been held in tropical Africa since 2003. The aim of these meetings is to promote communication among researchers and students interested in various aspects of African small mammal biology. The small mammals studied include rodents, insectivores, bats, afrotherians and small carnivores and primates, many of which are significantly understudied compared to their larger relatives.

The most recent ASMS took place on the 16–21 September, 2019, and was organised by Josef Bryja of the IVB and Yonas Meheretu of Mekelle University at the Mekelle University campus in Tigray, Ethiopia. The program included oral and poster presentations, with the oral presentations organised into blocks covering a wide range of scientific topics, e.g. pest management, systematics, phylogeography and evolutionary biology, disease ecology and epidemiology, ecology and conservation. There were 130 participants in all, 110 of which came from outside Ethiopia.

Researchers presenting at 13th ASMS were invited to submit papers for a special issue of the Journal of Vertebrate Biology (formerly Folia Zoologica) focused on African small mammals, which was subsequently published in 2020.

More information about the symposium can be found at: **https://asms2019.ivb.cz/**

Participant of the 13th African Small Mammal Symposium held at Mekelle in Ethiopia. | Photo from J. Bryja archive

5th Mouse meeting

The 5th Mouse Meeting, an international conference welcoming scientists from all over Europe, took place in Brno from 23–25 June 2019 at the Faculty of Economics and Administration of Masaryk University. The conference was organised by the Institute of Animal Physiology and Genetics of the Czech Academy of Sciences in cooperation with the IVB and Masaryk University.

Sixty-five participants attended the conference, including such well-known names as Jiří Forejt (Institute of Molecular Genetics, CAS), Jeremy Searle (Cornell University, USA), Robert Karn (University of Arizona, USA), Pierre Boursot (Université Montpellier II, France), Barbara König (University of Zurich, Switzerland), Diethard Tautz (Max-Planck Institute for Evolutionary Biology, Germany) and Dustin Penn (Konrad Lorenz Institute, Austria). This is the first time the meeting has been held in the Czech Republic, previous meetings having been held, for example, at the Max Planck Institute in Germany or, most recently, at the University of Zurich in Switzerland.

According to Miloš Macholán, the main organiser of the conference, previous years of the Mouse Meeting were partially devoted to establishing working collaborations between scientific groups, and this enabled the merging of partial collections of domestic mouse strains and closely related species derived from wild populations. This new collection, which is now located in the IVB breeding facility at Studenec, is unique in terms of its content and scope.

The welcoming talk of Miloš Macholán at the 5th Mouse meeting in Brno. | Photo from Institute of Animal Physiology and Genetics archive

The 4th Central European Hybrid Zone Meeting

The 4th Central European Hybrid zone Meeting, organised specifically for Czech Masters and PhD students and post-doctorate researchers, was held at the IVBs Mohelno field station on the 9–12 September 2019. Twenty-five participants attended the four-day event, including 20 from abroad. The workshop focused on different aspects of house mouse (*Mus musculus*) hybrid zones and was led by Stuart J. E. Baird (IVB) and Nick Barton (Institute of Science and Technology, Austria).

The 4th Central European Hybrid Zone Meeting
September, 9-12, 2019, Mohelno Field Station

Program:

Monday, September 9, 2019:
15:00 - 17:00 Arrival of participants to the Mohelno field station
17:00 Welcome party at the field station

Tuesday, September 10, 2019: chairman Z. Hladlovská
7:30 - 9:00 *Breakfast at the field station*
9:00 - 10:00 **Nick Barton**: Selection on flower colour in a snapdragion hybrid zone
10:00 - 10:30 **Daria Shipilina**: Balancing and divergent selection signatures in Snapdragon (*Antirrhinum majus*) genome
10:30 - 11:00 *Coffee break*
11: 00 - 11:30 **Marina Rafajlovic**: The effect of assortative mating on reproductive isolation in Littorina across Swedish hybrid zones
11:30 - 12:00 **Gertjan Bisschop**: Local adaptation in the face of global selection
12:00 - 14:00 *Lunch at the restaurant in Mohelno*
14:00 - 14:30 **Christelle Fraisse**: Introgression of sex-linked and autosomal genomic blocks between hybridizing species
14:30 - 15:00 **Stuart J. E. Baird**: The behaviour of a conflict system across a hybrid zone
15:00 - 15:30 *Coffee break at Mohelno field station*
15:30 - 16:00 **Beate Nurnberger**: A dense linkage map for the hybridising fire-bellied toads (Bombina)
16:00 - 16:30 **Ondřej Mikula:** Skull shape cline in the house mouse hybrid zone
17:00-18:00 Optional excursion to the The Mohelenská Serpentine Steppe National NP
18:30 *Dinner at the restaurant in Mohelno*

Wednesday, September 11, 2019: chairman S. J. E. Baird
7:30 - 9:00 *Breakfast at the field station*
9:00 - 9:30 **Alena Fornuskova**: Genomic study of Lymphocytic choriomeningitis virus across the house mouse hybrid zone
9:30 - 10:00 **Konrad Lohse**: Are sister species with contact zones less divergent than sympatric pairs?
10:00 - 10:30 *Coffee break*
10:30 - 11:00 **Kamil Joroň**: What keeps asexual hybrids heterozygous?
11:00 - 11:30 **Václav Gvoždík**: Slow-worm lizards (*Anguis*) - a new reptile model in hybrid zone studies
11:30 - 12:00 **Sean R Stankowski**: Genomic analysis of a hybrid zone in Monkeyflowers from the genus *Mimulus*
12:30 - 15:30 *Lunch at the restaurant and the brewery in Dalešice*
18:30 - 22:00 *Dinner at the restaurant in Mohelno or BBQ at the field station*

Thursday, September 12, 2019: departure day
7:30 - 9:00 *Breakfast at the field station and departure*

Program of the 4th Central European Hybrid zone Meeting

Participants of the 4th Central European Hybrid zone Meeting at the IVBs Mohelno field station. | Photo from IVB archive

Workshops and conferences focused on Eurasian lynx and grey wolf monitoring and conservation at the Czech-Slovak border

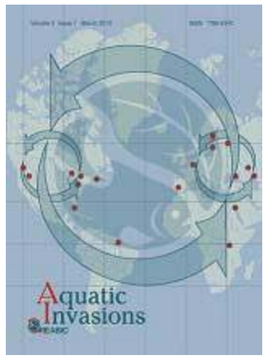
Between 2019 and 2020, researchers at the IVB, together with the Friends of the Earth, Czech Republic (Olomouc group), the State Nature Conservancy of the Slovak Republic and the Czech National Forest Centre, organised three workshops on Eurasian lynx (*Lynx lynx*) and grey wolf (*Canis lupus*) monitoring and conservation, with two of the meetings held in Slovakia in May and November of 2019 (Varín, Malá Fatra National Park and Papradno, Kysuce Protected Landscape Area, respectively) and one in the Czech Republic in October 2019 (Lidečko, Beskydy Protected Landscape Area). At these workshops, we informed stakeholder groups (e.g. conservationists, hunters, breeders, foresters, state administrations) about the progress of our project "Selmy SK-CZ" (funded through the EUs INTERREG V-A SK-CZ programme) and discussed relevant issues related to the conservation and management of large carnivores in these regions. At the November workshop In the Malá Fatra National Park, we set the groundwork for a conference focused on lynx and grey wolves in the Western Carpathians that was held in December 2019 at which the most important results from the Selmy SK-CZ project were presented and presentations related to this issue were presented. These events were attended by 139 participants from Slovakia and the Czech Republic.

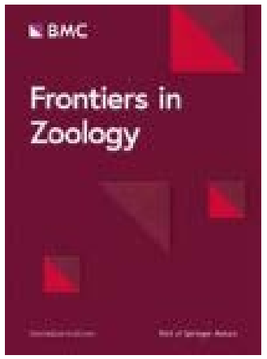
The Eurasian lynx and grey wolf monitoring stakeholder workshop held at Varín in the Malá Fatra National Park (Slovakia) in December 2019. | Photo by M. Barančeková

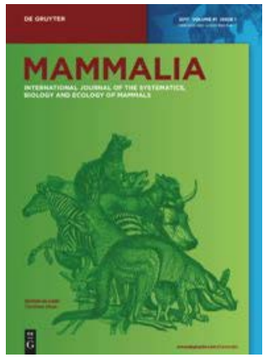
The Eurasian lynx and grey wolf monitoring stakeholder workshop held at Lidečko in the Beskydy Protected Landscape Area (Czech Republic) in October 2019. | Photo by J. Krojerová

MEMBERSHIP OF EDITORIAL BOARDS

In 2019 and 2020, our scientists acted as Associate Editors on a number of international peer-reviewed journals, including Evolution, Evolutionary Ecology, Mammalia, Frontiers in Zoology, Frontiers in Ecology and Evolution and Bioinvasions Records. A number of researchers at the IVB are also editorial board members for international peer-reviewed journals, including Herpetology Notes, Cryobiology, International Journal of Primatology, Zoology and Ecology, Journal of Vertebrate Biology (formerly Folia Zoologica), Comparative Cytogenetics, Mammal Research, Acta Zoologica Bulgarica, Archives of Biological Science, International Studies on Sparrows, The Scientific World Journal and the Croatian Journal of Fisheries.



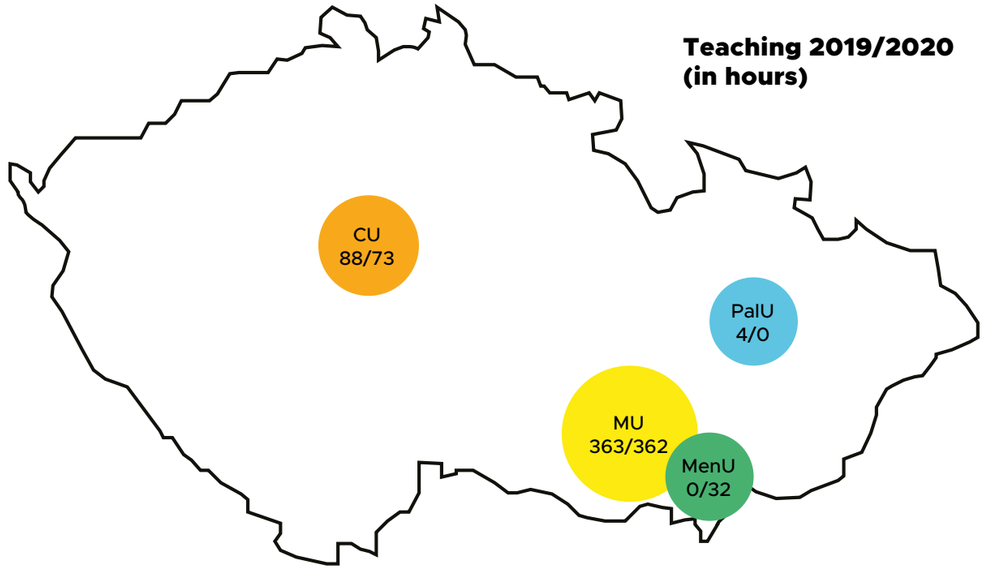




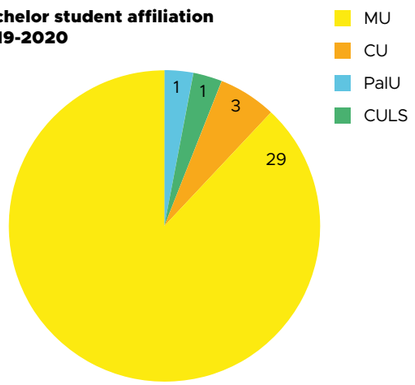
EDUCATION AND TEACHING ACTIVITIES

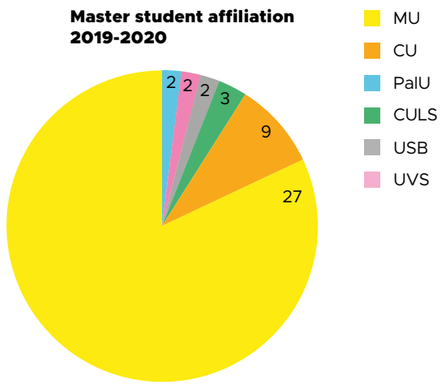
Teaching at universities and supervision of students

IVB employees have been very active in lecturing at universities around the country providing a total of 455 hours of lectures in 2019 and 467 hours in 2020. Many graduate students are also involved in IVB research programs. The Institute's researchers supervised 34 Bachelor and 45 Masters students over 2019-2020, with 17 students graduating in 2019 (six Bachelors and 11 Masters) and 20 students graduating in 2020 (eight Bachelors and 12 Masters).



Number of hours IVB researchers spent lecturing at Czech universities in 2019 and 2020. MU = Masaryk University, Brno; MenU = Mendel University in Brno; PalU = Palacký University, Olomouc; CU = Charles University, Prague. Numbers in circles indicate hours of lecturing in 2019/2020, respectively.





Affiliation and number of Bachelor and Masters students supervised by IVB researchers in 2019 and 2020. MU = Masaryk University, Brno; CU = Charles University, Prague; CULS = Czech University of Life Sciences, Prague; USB = University of South Bohemia, České Budějovice; PalU = Palacký University, Olomouc; UVS = University of Veterinary Sciences, Brno.

PhD students working at the Institute and/or supervised by the Institute's fellows

Over 2019 and 2020, researchers at the IVB supervised 44 PhD students, six of which successfully defended their theses during that period.

Table 1: Table 1: List of PhD students supervised by IVB researchers over 2019 and 2020.

PhD student	Supervisor/Consultant*	Start of study	Defended thesis	Faculty
ADÁMKOVÁ Marie	Albrecht/Tomášek*	2013		1
ALILA Okinyi David	Seehausen/Reichard*	2019		7
BADJEDJEA BABANGENGE Gabriel	Gvoždík V.	2017		4
BAŚKIERA Senka	Gvoždík L	2017		1
BOBEK Lukáš	Albrecht/Tomášek*	2013		1
BRLÍK Vojtěch	Procházka	2019		2
CUYPERS Laura	Goüy de Bellocq/ Baird*	2017		3
DAŇKOVÁ Renata	Šálek*	2013	2020	9
DIANAT Malahat	Bryja*	2018		1
DOLINAY Matej	Gvoždík V	2015		1
GARCÍA Daniel	Reichard	2015	2019	6
HÁNOVÁ Alexandra	Bryja*	2016		1
HARAZIM Markéta	Martínková	2018		1
HEGER Tomáš	Zukal	2017		8
HORÁK Kryštof	Albrecht	2019		1
ILÍK Vladislav	Pafčo	2020		1
JIROUŠOVÁ Eva	Pafčo*	2020		1
KAUZÁL Ondřej	Albrecht/Tomášek*	2017		2
KEJÍKOVÁ Romana	Rudolf	2020		1
KLUSÁČKOVÁ Pavla	Piálek	2020		1
KUMAR Sampath Anandan	Tomášek/Albrecht*	2017		1
LOTANA LOKASOLA Albert	Gvoždík V.	2018		4
MARTINCOVÁ Iva	Piálek	2012	2019	1
MASON Bethan	Petrželková	2019		1
MAZOCH Vladimír	Bryja*	2009	2019	5
MÍČKOVÁ Kristýna	Albrecht	2018		2
MICHÁLKOVÁ Romana	Albrecht	2012		2
MIKULA Peter	Albrecht	2015	2020	2
MIZEROVSKÁ Daniela	Bryja	2018		1
MULUALEM Getachew	Bryja	2020		1
NEČAS Tadeáš	Gvoždík V	2019		1
PAZDERA Lukáš	Tomášek/Albrecht*	2020		2
PETRUŽELA Jan	Goüy de Bellocq/ Baird*	2018		1
PRAVDOVÁ Markéta	Ondračková	2015		1
PROKOPOVÁ Tereza	Pafčo*	2019		8
PTÁČKOVÁ Olga	Albrecht	2018		1
SAU Shubhra	Martínková	2021		1
SNÍTILÝ František	Gvoždík V	2019		1
SOSNOVCOVÁ Kateřina	Procházka/Koleček*	2015		2
ŠLAPANSKÝ Luděk	Jurajda	2012	2019	1
TĚŠÍKOVÁ Jana	Goüy de Bellocq / Bryja*	2014		1
TURBAKOVÁ Barbora	Bryja/ Krojerová*	2015		1
VOJTÍŠEK Jakub	Rudolf	2020		1
ŽÁK Jakub	Reichard	2017		2

** FACULTY: 1 = Faculty of Science, Masaryk University, Brno; 2 = Faculty of Science, Charles University, Prague; 3 = University of Antwerp; 4 = Université de Kisangani, Faculté des Sciences, RD Congo; 5 = Faculty of Science, University of South Bohemia, České Budějovice; 6 = Universidad de la República, Montevideo, Uruguay; 7 = Institute of Ecology & Evolution, University of Bern, Switzerland; 8 = Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences, Brno; 9 = Faculty of AgriSciences, Mendel University, Brno.

PhD theses supervised by Institute fellows that were defended in 2019 and 2020

DAŇKOVÁ Renata, 2020: *Ornithocenoses of agrarian terraces of South Moravia.* Faculty of AgriSciences, Mendel University in Brno. Co-supervisor: M. Šálek.

GARCÍA Daniel, 2019: *Consecuencias de las presiones selectivas sobre la evolución de la historia de vida en peces con envejecimiento rápido.* Universidad de la República, Montevideo, Uruguay. Supervisor: M. Reichard.

MARTINCOVÁ Iva, 2019: *Spermatogenetic defects in mouse hybrids.* Faculty of Science, Masaryk University, Brno. Supervisor: J. Piálek.

MAZOCH Vladimír, 2019: *Diversity, evolution, and distribution of selected African rodents, with focus on East African savannahs.* Faculty of Science, University of South Bohemia, České Budějovice. Co-supervisor: J. Bryja.

MIKULA Peter, 2020: *Environmental effects on acoustic and visual signalization in birds: combination of regional and global perspectives.* Faculty of Science, Charles University, Prague. Supervisor: T. Albrecht.

ŠLAPANSKÝ Luděk, 2019: *Movement activity of non-native Gobiids.* Faculty of Science, Masaryk University, Brno. Supervisor: P. Jurajda.

PhD defence and graduation of Iva Martincová. | Photo from I. Martincová archive

EDITORIAL ACTIVITIES

Journal of Vertebrate Biology

The Institute of Vertebrate Biology publishes the *Journal of Vertebrate Biology* jointly with the Faculty of Environmental Sciences of the Czech University of Life Sciences in Prague. The Journal, which was formerly known as *Folia Zoologica*, has an origin reaching back more than 80 years. This international impacted Journal focuses on the behaviour, ecology, physiology, anatomy, developmental biology, taxonomy and evolution of vertebrates, with a particular focus on interdisciplinary research.

The new chief editors of the *Journal of Vertebrate Biology* are Prof. Carl Smith (University of Łódź, Poland) and Prof. RNDr. Vladimír Bejček, CSc. (Faculty of Environmental Sciences, Czech University of Life Sciences, Prague, Czech Republic). The Journal is published by BioOne, who provide full-text articles. The content is Open Access, with all articles and related material freely available. There is no charge for submission of manuscripts to the journal and the review process is extremely rapid, with authors typically receiving an editorial decision on their manuscript within three weeks. Non-English speakers also receive assistance with English correction of their manuscript.

In 2020, the Journal published a Special Issue on African Rodents, comprising 17 articles from authors across Europe, Africa and the USA. The issue covered a range of research topics, including the evolution, phylogeny, diseases, taxonomy and diversity of small mammals. A second special issue focused on the role of dogs in conservation, which comprised 14 papers from seven African and European countries, addressed the novel practice of using dogs for wildlife protection, tackling poaching, detecting illegal poisons and surveying wildlife populations.

Dogs used for conservation activities in a range of settings. | Photo from Working Dogs for Conservation archive

Publisher and Editorial Office

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Aims & Scope

The **Journal of Vertebrate Biology** is an international journal covering all fields of vertebrate zoology. The journal welcomes papers on the behaviour, ecology, physiology, anatomy, developmental biology, taxonomy and evolution of vertebrates, including research at the interface of these disciplines. The journal is published quarterly, with one volume comprising four issues, with additional issues published occasionally.

The journal is indexed in
+ EBSCO
+ Gale/Cengage Learning
+ Elsevier Bibliographic Databases, incl. Scopus
+ Clarivate analytics Databases, incl. Web of Science

The journal is available online through
+ BioOne
+ Digital Library Kramerius

Full papers published in the Journal of Vertebrate Zoology are available on https://www.jvertbiol.cz/index.php

Submission of manuscripts
All manuscripts should be submitted online. Full upload instructions and support are available online from the submission site https://www.jvertbiol.cz/submission.php. Please submit a covering letter or comments to the Editor-in--Chief when prompted. In order to facilitate the peer-review process, authors are requested to suggest a minimum of three reviewers.

Format

Manuscripts can be published as original research papers, short notes, reviews or monographs. Papers or reviews must not exceed 30 manuscript pages, including references, figures and tables. There is no page limit for monographs.

More information on the submission process can be found at: https://www.jvertbiol.cz/submission.php

Benefits to authors

+ Open Access
+ No publication charges
+ Rapid reviewing
+ No formatting required for initial submission
+ Assistance with English correction for non-native speakers

AWARDS

The Vojtěch Náprstek Honorary Medal for merit in popularisation (Czech Academy of Sciences)

The Vojtěch Náprstek Medal for Merit in Popularising Science was introduced by the Czech Academy of Sciences in 2002 and is awarded not only to employees of the Academy and scientists, but also to those who deal with the popularisation of science in their daily activities.

Martin Šálek, who focuses on a wide range of topics including the protection of little owls in Central Europe, support of biodiversity in agricultural landscapes, alternative management of ecosystems and nature protection, the spread of invasive species, the recovery of European elk populations in the Czech Republic and owl mapping, has been awarded the Vojtěch Náprstek Honorary Medal for his services in popularising science.

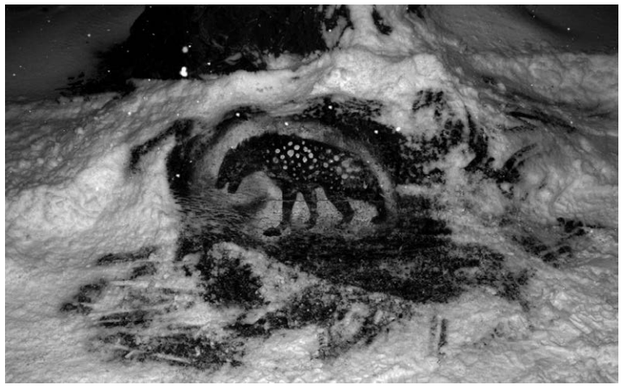
"Popularisation is a natural part of scientific work: the media have enormous power and we need to work with people, we need their help and some pressure. For example, at a time of volcanic digestion, pressure from the media, civic initiatives and scientific institutions helped, and it came to a halt. It has not yet been completely won, but it has been a success", said Martin Šálek, adding that we live in a time of man-made changes and manners: climate change, the spread of non-native species, the extinction of native ones...

Martin Šálek (right) upon receiving the Vojtěch Náprstek Medal for Merit in Popularising Science. | Photo from the CAS archive

Photogenic Science (Czech Academy of Sciences)

The “Photogenic Science” project was instigated as part of Forum Science’s “Science Lives!” campaign with the goal of organising an annual photography competition for employees of the Czech Academy of Sciences and its workplaces. Each year, selected images are reproduced in a representative calendar and are presented as part of the exhibition “Photogenic Science”, which first takes place in Prague but then moves on to other towns, both in the Czech Republic and other parts of the world. The competition serves to promote the Academy of Sciences of the Czech Republic as a whole and, in addition to its popularisation function aimed at the public, helps identify employees with the brand of the Czech Academy of Sciences.

In 2019, Martin Šálek won 1st place in the main category with his photo “Farmer Jarda and the little owl”, while Michal šulc won second place in the main category with his picture “Lighting new life inside the egg”. In 2020, Martin Šálek won 3rd place in the main category with his photo to depicting a cave hyena. The winner’s photos formed part of the official calendar of the Czech Academy of Sciences.



Winning photos in the “Photogenic Science” competitions of 2019 and 2020.
Lighting new life inside the egg | Photo by M. Šulc
Framer Jarda | Photo by M. Šálek
Cave hyena | Photo by M. Šálek

Fulbright scholarship

The prestigious Fulbright Program, sponsored by the governments of the United States and Czech Republic, provides U.S. and Czech citizens with the opportunity to study, teach or conduct research in the partner country. The Fulbright Program is open to all fields, be it Liberal Arts or Hard Sciences (except for MBA, LLM and Clinical Medicine). Proposals in American Studies and Central European studies are welcome, as well as proposals for studying intercultural or interdisciplinary aspects. The academic quality of proposals is decisive for obtaining awards. Preference may be given to those without prior experience in the partner country, provided the overall quality of submitted projects is comparable.

In 2019 Milan Vrtílek won a Fulbright scholarship, allowing him stay at the University of Connecticut-Storrs (USA) for four months. He gained the scholarship based on his project proposal “Maternal Immunity Effects”.

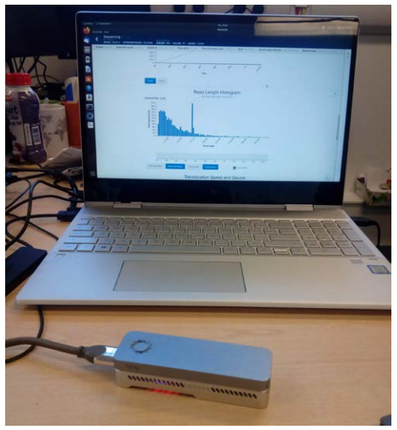
Milan Vrtílek, who won a Fulbright scholarship allowing him to stay at the University of Connecticut-Storrs (USA) for four months.
| Photo from IVB archive

Godfrey Hewitt Mobility Award (European Society for Evolutionary Biology)

Godfrey Hewitt (1940–2013) was President of the European Society for Evolutionary Biology (ESEB) from 1999–2001. He was exceptionally influential in the field of evolutionary biology, both through his research and through his mentoring of young scientists. He was also a great believer in seeing organisms in their environment first-hand and in the exchange of ideas between laboratories. To commemorate this exceptional scientist, each year the ESEB offers mobility grants for young scientists in his name.

In 2019, Alena Fornůsková of the IVB received a Godfrey Hewitt Mobility Award. Alena won the grant in 2018 as part of the 4th call for the Czech Academy of Science's Program 'Research and Mobility Support for Starting Researchers', based on her project investigating whether geographically and genetically distinct subspecies of the house mouse (*Mus musculus*) carry distinct lymphocytic choriomeningitis virus (LCMV) strains, which formed part of the project "*Genomic Study of Lymphocytic Choriomeningitis Virus across the House Mouse Hybrid Zone*". As part of the project, she had planned a foreign stay at the University of Edinburgh (UK) in order to learn how to analyse long read data produced by nanopore-based DNA sequencing. However, with two small children (four- and two-years-old at that time), relocation of the whole family was going to be financially demanding. Thanks to the Godfrey Hewitt Mobility Award, Alena was able to balance care of her children (both went to nursery school while in Edinburgh) and work.

A. Fornůsková with her family in Edinburgh in 2019. | Photo from A. Fornůsková archive



MinION - the portable, real-time devices for DNA and RNA sequencing. | Photo from A. Fornůsková archive

OBITUARY

RNDr. Věra Holišová, CSc. 1930–2019

M. Heroldová and J. Zejda

One of the outstanding scientists from the Institute of Vertebrate Biology, CAS founders was Věra Holišová. She was a very diligent, modest and hardworking woman. She was born on 11th of August 1930 in Brtnice near Jihlava. She studied at the Faculty of Natural Sciences in Brno (today Masaryk University) and graduated in 1953. She entered the Vertebrate Research Laboratory in Brno (later Institute of Vertebrate Zoology of the CSAS and now Institute of Vertebrate Biology, CAS) in 1954.

As to research activities she was concentrated, from the very beginning, on mammalogy. With her colleagues J. Pelikán and J. Zejda and in time with others, who formed a research group, they concentrated on the basic research of the small mammals. It was time to create a methodological basis of the research such as verification of trapping methods and its effectiveness (trapping quadrats and lines), various types of traps and its effectiveness, its spacing, number of trapping days, and marking of individuals.

Important were also to fix standards of morphometry of the animals for exact species determination under autopsy. Last but not least was all collected data coherent logging in protocols and so on. Dr. Holišová was in this team extremely beneficial. She was an excellent field zoologist. As she knew botany well it was obvious that feeding strategy of herbivorous species would be her main theme of her scientific career.

One of her first research topic was diet of the common vole. This was to be part of a monograph on the common vole, under the leadership of prof. J. Kratochvíl, which was published in 1959 written in Czech with German summary. Small herbivorous mammals, especially common vole, grind the food, while they eat, on very small particles of plant tissue and microscopic analysis of their diet is demanding a good knowledge of the plant anatomy but also experience and time.

She built a collection of plant anatomy slides (standards) from plants from all localities she studied, alphabetically lined by its Latin names, available in Institute Collections. Similar comparative collection was built of the plant seeds material and both are available for any similar study on herbivorous diet.

She studied the diet of many species of small mammals by microscopic analysis. Some of them are the only information on a particular species' diet. As an example it is publication on feeding strategy of *Apodemus uralensis* (previously *A. microps*) and also monograph on this species biotope requirement. Other studied species, as to their diet, were *Apodemus sylvaticus*, *A. flavicollis*, *A. agrarius*, M*icrotus subterraneus*, *Arvicola terrestris* (from various environments), *Muscardinus avellanarius* and *Mus musculus*.

She deeply studied the food of forest species *Clethrionomys glareolus* in various types

of biotopes, in various population densities in lowland forests, oak and pine forests, in spruce monoculture and in mountain forests.

Very fruitful was her cooperation with Dr. Obrtel, who introduced more of the statistics to the diet evaluations and with that, broader ecological insight. This enables a broader context of production processes in ecosystems with continuity to botanical and entomological research activities. Foraging strategies of individual species and their diet niches were connected in comparing niches overlapping and diet similarities in various forests and open land environments. This resulted in many publications and monographs on the mutual relationship of rodents and their food requirements.

Beside this she participated in joint research on biotope demands of various species in forests and in agroecosystems as well as on monographs on mammals in Brno city.

She also studied the ethology of species such as vertical movement of small mammals in forest or home range size of *Arvicola terrestris* or daily activity of *A. sylvaticus*. Very laborious was her work on spatial activity of rodents.

As frequently travelling to her weekend house in Brtnice, she collected vast material on influence of traffic to various species of vertebrates divided into impact of various types of roads.

At the end of her research career, when the department turned to study ungulate species, she studied the all year round diet of field roe deer in South Moravian agroecosystems. In response to this she studied the impact of roe deer on sugar beet and on maize during the growing season. She participated in the study on diet supply for roe deer and hare in a highly agricultural landscape. Her other joint studies were diet of sika deer in Manetin and Bouzov area and chamois in Jeseniky Mts.

She dedicated her life to high quality research activities and especially her studies on herbivorous diet are unique and still frequently cited.

In her private life she loved listening to classical music (primarily Janáček, Martinů and Mahler) and Czech and world poetry. She died at the end of the year 2019 in her 89 years.

OBITUARY

prof. RNDr. Jan Zima, DrSc.
1952–2019

IN MEMORY OF HONZA ZIMA

Josef Bryja

“Fig.: Honza hands out “diplomas” to the winners of the children’s competition during one of many informal meetings with a roast pig and a keg of beer at the playground “behind the houses” in Studenec.

I write these sentences from my office in one of the most famous natural history museums, the Muséum National d´Histoire Naturelle in Paris. The office was lent to me for a couple of months by Prof. Christiane Denys, one of the world’s great experts in the study of the diversity of contemporary and fossil mammals, especially African rodents. This would probably never have happened if I had not met Honza (Jan) Zima as a student. Honza was always able to correctly identify which (often untested) way to go and directed his students and co-workers there as well. Based on his recommendations I started to study the genetic diversity of mammals (and then many other animals) and I flew to Africa for the first time to capture and karyotype rodents and bats. I also went with him across Europe to Santiago de Compostela in an old cyan Škoda Favorit car to participate at my first scientific conference (and then at many others), where he introduced me to the greatest names in his field, people with whom I still cooperate today.

At the end of 1990s, as Director of the Institute, Honza was instrumental in saving the Studenec workplace and, with the beginning of the new millennium, started its boom development. Without him, dozens of people who today are discovering the secrets of nature at this top-level research facility, would be looking for fulfilment elsewhere. Throughout his outstanding career, he remained a normal person who was able to combine natural authority with a human approach and a sense of humour in a truly unique way.

During many informal events and celebrations “behind the houses” in Studenec, we always looked forward to his arrival from Brno or Prague. It was an honour for us that he wanted to organise the official celebration of his sixtieth birthday (with a whole pig barbecue and a beer keg next to the fireplace) in Studenec.

May someone, sometime, remember us as much as we remember Honza Zima.”

Tomáš Albrecht

“For me, Honza was definitely one of the most important figures influencing my scientific career. Over more than 20 years of sometimes formal, and more often very informal, interactions, starting during my studies at the Faculty of Science at Charles University in Prague and continuing at the IVB, he shaped my opinion on what scientific work and university teaching should be like.

Despite the fact that he was never my official supervisor, and he never taught me directly (even though he examined me at the Master‘s state examination, where, I still remember perfectly, we talked for a long time about mountain beavers), I will always proudly consider myself one of his numerous students and scientific followers!”

Lenka Glosová

“I worked with Honza from the spring of 2005 until the spring of 2019. I remember him as a man with a truly human approach and understanding. He was extremely hardworking, responsible, helpful and friendly.

He was an excellent storyteller and his stories made me laugh a lot. He was a great boss and an exceptional person.”

Barbora Rolečková

“A few months before Honza died, when he was already going to work only rarely, we met in the Nika restaurant, where people from the Květná workplace used to go for lunch. While we were ostensibly having a working meeting regarding the preparation of posters on the history of the institute, we mainly talked about life.

I mentioned our family vacation in the Slovak Karst National Park and that was “water to Honza’s mill”. It turned out that I had nothing to explain to him about the place; together with Ivan Horáček and other high school classmates they had probably crawled through every single cave there trying to find all the bats.

From other stories (for example, those about his winter expeditions to high mountains with only an old-fashioned “blanket” sleeping bag), I understood that Honza was force of nature when he was young; that he probably had lived his life much more intensely than many others.

I also realised how strange it is, and yet how common, that when a person is finally running out of energy, it can appear to others as if they have always been as they are, and yet one can be truly surprised when they learn a bit more about that person’s life. I know that, despite passing away early, Honza managed to experience a lot.

RESEARCH PROJECTS

PROJECTS SUPPORTED BY THE CZECH SCIENCE FOUNDATION (GA ČR)

GA17-15480S Freshwater ectotherms under climate change: the role of phenotypic plasticity in life histories and trophic interactions. **Recipient:** University of South Bohemia in České Budějovice. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** David Boukal. Principal Co-Investigator: Lumír Gvoždík. **Research years:** 2017-2019.

GA17-09807S Why and how animals abandon sex? On the causal role of hybridization in triggering asexual reproduction. **Recipient:** Institute of Animal Physiology and Genetics, Czech Academy of Sciences, Brno. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Karel Janko. Principal Co-Investigator: Karel Halačka. **Research years:** 2017-2019.

GA17-04364S The role of Prdm9 allelic variations and activity in hybrid sterility in mice. **Recipient:** Institute of Molecular Genetics, Czech Academy of Sciences. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Emil Parvanov. Principal Co-Investigator: Jaroslav Piálek. **Research years:** 2017-2019.

GA17-20284S Physiology of bat hibernation with respect to multistressor impacts. **Recipient:** University of Veterinary and Pharmaceutical Sciences, Brno. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jiří Pikula. Principal Co-Investigator: Natália Martínková. **Research years:** 2017-2019.

GA17-12262S Reproductive strategies of an obligate brood parasite: host selection, offspring sex allocation and individual success. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Marcel Honza. **Research years:** 2017-2019.

GA17-24782S Latitudinal and altitudinal patterns in avian pace-of-life syndromes: a study of Afrotropical and European songbirds. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Tomáš Albrecht. **Research years:** 2017-2019.

GA17-25320S Genotypes and phenotypes associated with Y chromosome introgression in the European house mouse hybrid zone: comparison among transects. **Principle Investigator:** Stuart J. E. Baird. **Research years:** 2017-2019.

GA18-14325S The genetic basis of species origin: What can we learn from organisms with female heterogamety? **Recipient:** Charles University in Prague. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Radka Reifová. Principal Co-Investigator: Tomáš Albrecht. **Research years:** 2018-2020.

GA18-17398S Evolution at steep elevational gradients: assessing the role of genetic and ecological factors in speciation processes. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Josef Bryja. **Research years:** 2018-2020.

GA 18-19629S Comparative parasite hybridisation genomics controlling for host divergence. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Joelle Gouy de Bellocq. **Research years:** 2018-2021.

GA18-24544S Genomic insights into the evolutionary history and contact zones of slow-worm lizards (Anguis). **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Václav Gvoždík. **Research years:** 2018-2021.

GA18-17796Y Consequences of vertebrate microbiota changes due to symbiotic associations with humans. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jakub Kreisinger. **Research years:** 2018-2021.

GA18-24345S Epidemiology and pathological effects of gastrointestinal helminthiases in critically endangered mountain gorillas. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Klára Petrželková. **Research years:** 2018-2021.

GA18-26284S Embryo and environment – annual fish as a unique model to study embryo ecology. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Matej Polačik. **Research years:** 2018-2021.

GA18-00682S A novel system to understand brood parasitism: the cuckoo catfish parasiting African cichlids. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Martin Reichard. **Research years:** 2018-2021.

GA19-22538S Molecular mechanisms of sperm morphology variation in passerine birds. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Tomáš Albrecht. **Research years:** 2019-2021.

GA19-20873S Driver mutations in cancer genome of Nothobranchius furzeri: from tumor biology to concept of experimental model of spontaneous carcinogenesis. **Recipient:** Masaryk University in Brno, CEITEC. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Ondřej Slabý. Principal Co-Investigator: Radim Blažek. **Research years:** 2019-2021.

GA19-19307S Evolutionary patterns of gastrointestinal microbiota on murine rodents example. **Recipient:** Charles University in Prague. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jakub Kreisinger. Principal Co-Investigator: Dagmar Čížková. **Research years:** 2019-2021.

GA19-12774S Evolution of hybrid male sterility in the European house mouse. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jaroslav Piálek. **Research years:** 2019-2021.

GA19-01781S The sources of intra-population heterogeneity in senescence. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Martin Reichard. **Research years:** 2019-2021.

GA19-05510S Individual variability and resilience of interspecific relationships in freshwaters: insights from fishmussel interactions. **Recipient:** Czech University of Life Science in Prague. Sub-**Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Karel Douda. Principal Co-Investigator: Martin Reichard. **Research years:** 2019-2021.

GA20-23794S Germ-line restricted chromosome in songbirds: understanding its origin, function and evolutionary significance. **Recipient:** Charles University in Prague. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Radka Reifová. Principal Co-Investigator: Tomáš Albrecht. **Research years:** 2020-2022.

GA20-10222S Phylogeny, adaptation and evolution of sociality in African mole-rats, a model group in evolutionary and biomedical research. **Recipient:** University of South Bohemia in České Budějovice. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Radim Šumbera. Principal Co-Investigator: Ondřej Mikula. **Research years:** 2020-2022.

GA20-29111S Parasite acquisition by non-native fish hosts: determinants and impacts on native fish fauna. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Markéta Ondračková. **Research years:** 2020-2022.

GA20-00648S Integrating migratory patterns, phenology, year-round habitat use and demography to understand drivers of population dynamics of migratory birds. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Petr Procházka. **Research years:** 2020-2022.

GA20-006110Y Conspecific brood parasitism in an altricial passerine: physiological conditions, behavioural adaptations and fitness consequences. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Michal Šulc. **Research years:** 2020-2022.

GA20-07091J Small mammals of Eastern African Mountains: evolutionary diversification and endemism in one of the world´s most important biodiversity hot-spots. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Josef Bryja. **Research years:** 2020-2022.

PROJECTS SUPPORTED BY THE TECHNOLOGY AGENCY OF THE CZECH REPUBLIC (TA ČR)

TG03010048 Commercialization of results of zoological research - applications for nature conservation. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jan Zukal. **Research years:** 2016-2019.

PROJECTS SUPPORTED BY THE MINISTRY OF EDUCATION, YOUTH AND SPORT OF THE CZECH REPUBLIC

OP VVV MEZEK International collaboration in ecological and evolutionary biology of Vertebrates. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Josef Bryja. **Research years:** 2018-2020.

LTAUSA18209 The impact of diet and the gut microbiome on risk of cardiometabolic diseases in western lowland gorillas. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Klára Petrželková. **Research years:** 2019-2022. Managed by: The Ministry of Education, Youth and Sport of the Czech Republic.

LTAUSA19092 Genetic variability and parasitism in one of the most successful fish invader across in Europe. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Markéta Ondračková. **Research years:** 2020-2022. Managed by: The Ministry of Health of the Czech Republic.

LTAUSA19147 Evolution and speciation mechanisms in a cryptic species complex of pan-African bats. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Peter Vallo. **Research years:** 2020-2022. Managed by: The Ministry of Education, Youth and Sport of the Czech Republic.

INTER-COST LTC20021 Conservation genetics and genomics of vertebrate species in Central European region. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Josef Bryja. **Research years:** 2020-2023. Managed by: The Ministry of Education, Youth and Sport of the Czech Republic.

PROJECTS SUPPORTED BY THE MINISTRY OF HEALTH OF THE CZECH REPUBLIC

NV19-09-00036 Preparedness for introduction of exotic mosquito-borne viral fevers - One Health approach. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Ivo Rudolf. **Research years:** 2019-2021.

INTERNATIONAL PROJECTS

ATHENE Care for the largest residual populations of the European owl. **Recipient:** Czech Society for Ornithology. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. Principle Investigator at IVB: Martin Šálek. **Research years:** 2014-2020. The ATHENE project is part of the Czech Republic - Free State of Saxony 2014-2020 cross-border Cooperation Program. This project is supported by the European Union under the European Regional Development Fund.

Interreg V-A SK-CZ Coordination of the management of Eurasian lynx and grey wolf populations in the Western Carpathians. **Recipient:** State Nature Conservancy of the Slovak Republic. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. Principle Investigator for the Czech Republic: Jarmila Krojerová-Prokešová. **Research years:** 2017-2019.

Interreg 304021D016 Koordinácia ochrany, monitoringu a manažmentu západokarpatskej populácie vlka dravého a rysa ostrovida na česko-slovenskom pomedzí (Coordination of the management of Eurasian lynx and grey wolf populations in the Western Carpathians). **Recipient:** State Nature Conservancy of the Slovak Republic. **Sub-Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. Principle Investigator for the Czech Republic: Petr Koubek. **Research years:** 2018-2019.

EU COST CA17108 Aedes Invasive Mosquitoes. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Ivo Rudolf. **Research years:** 2018-2022.

JMK059209/19/OKH Monitoring of mosquitoes on West Nile. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Ivo Rudolf. **Research years:** 2019.

JPN Mobility PLUS Morphological and molecular identification of parasitic nematodes in non-human primates: strengthening the connection between traditional and modern approaches. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Klára Petrželková. **Research years:** 2019-2021.

COST CA18134 Genomic blodiversity knowledge for resilient ecosystems. **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Josef Bryja. **Research years:** 2019-2023.

304021R971 Hledáme kočku, pozor, divokou! (We are looking for a cat, a wildcat!) **Recipient:** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. **Principle Investigator:** Jarmila Krojerová-Prokešová. **Research years:** 2020-2021. Financed by: Interreg V-A SK-CZ.

COMPLETE LIST OF PUBLICATIONS

Books, textbooks, edited proceedings

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BRYJA J, KURAS T, TUF IH, TKADLEC E (eds), 2020. Zoologické dny Olomouc 2020. ÚBO AV ČR, Brno, 250 pp. ISBN 978-80-87189-32-0.

SEARLE JB, POLLY DP, ZIMA J (eds), 2019. *Shrews, chromosomes and speciation*. Cambridge University Press, Cambridge, 475 pp. Cambridge studies in morphology and molecules. New paradigms in evolutionary biology. ISBN 978-1-107-01137-3.

Chapters in books

ADÁMEK Z, JURAJDOVÁ Z, JANÁČ M, ZAHRÁDKOVÁ S, NĚMEJCOVÁ D, JURAJDA P, 2020. The response of fish assemblages to human impacts along the lower stretch of the rivers Morava and Dyje (Danube River Basin, Czech Republic). In Bănăduc D, Curtean-Bănăduc A, Pedrotti F, Cianfaglione K, Akeroyd JR (eds). *Human impact on Danube watershed biodiversity in the XXI century*. Springer Nature Switzerland, Cham: 135-149. Geobotany Studies. ISBN 978-3-030-37241-5.

REICHARD M, 2020. Evolutionary theories of aging. In Rattan SIS (ed.). *Encyclopedia of Biomedical Gerontology*. Academic Press, London: 57-67. ISBN 978-0-12-816075-6.

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ADÁMEK Z, MIKL L, ŠLAPANSKÝ L, JURAJDA P, HALAČKA K, 2019. The diet of predatory fish in drinking water reservoirs how can they contribute to biomanipulation efforts? *Folia Zoologica* **68**: 215-224.

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BAIRD SJE, GOÜY DE BELLOCQ J, 2019. Shifting paradigms for studying parasitism in hybridising hosts: response to Theodosopoulos, Hund, and Taylor. *Trends in Ecology & Evolution* **34**: 387-389.

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